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Contents.

Notes and Comments	575
A Moulding Shop of the Eighteenth Century.—II.	577
Gating Non-Ferrous Metal Castings	579
Some Properties of Ingots	584
Gas Furnaces and their Utility	590
The Use and Abuse of Glue	591
Use of Borings in Cupola Operations	592
Match Plates and Aluminium Patterns	593
Manufacture of Alloy Steels	594
British Foundrymen's Associations—	
Scottish Branch	597
London Branch	597
Moulding Shells	598
Flexible Chiller	599
The Ideal Electric Furnace for the Steel Foundry	600
Use of Grey-Iron Scrap	602
Effect of Sulphur on Low-Carbon Steel	603
Queries and Replies	604
Crude Oil for Cupola Melting	604
Non-Ferrous Notes	605
Trade Talk	606
Applications for Patents	608
Legal	608
Munition Making	608
Deaths	610
Personal	612
New Companies	612
Monthly Price List	614

Forthcoming Events.

NOVEMBER 17.

British Foundrymen's Association: London Branch.—Lecture to be arranged.

NOVEMBER 18.

British Foundrymen's Association: Scottish Branch.—"Cast-Iron," by E. Adamson (Sheffield).

NOVEMBER 25.

British Foundrymen's Association: Birmingham Branch.—"Notes on the Influence of Gases in Iron and Steel," by J. E. Fletcher.

NOTES AND COMMENTS.

Things the Foundryman Needs to Know.

A prominent engineer, discussing with us the subject of foundry work, recently referred to the steel-moulder's work as being a sort of secret art, of which little was known. It would perhaps be more nearly correct to say the steel-moulder's craft was one of much secretiveness and few secrets. Very many steel moulders maintain the attitude that gives rise to such ideas as that quoted above, but it is pitiable the amount of ignorance and prejudice which that secretiveness covers. Almost every steel moulder has exclusive knowledge of the "best" moulding composition, on which the success of his trade depends, and scarcely any two are alike. Science and experience may offer an admirable moulding material of a known nature, but prejudice prohibits its use in regular practice. Is it not time, in the interests of the trade and of national economy, that some authority or constituted body took up properly such questions as this? Our knowledge of sands and their uses in moulding is in a really chaotic condition, but to whom or what can we turn for reliable guidance? There should be nothing secret about a trade which is so vital to our national welfare, and which is so essentially based on matters within range of practical and scientific research.

On the uses of alloys, also, there is little guidance to be obtained by engineer or founder in the matter of the most suitable alloy for a particular purpose. Few men can obtain the necessary experience with the large range of possible metals to be able to say what is best for any new application; nor is there any definite source to which they can apply for the information. The designer will often specify some particular "bronze," simply because the name strikes his fancy, and is associated with exceptional physical properties. But as to its actual suitability he is generally ignorant.

Ignorance of such subjects outside the founders' ranks is perhaps understandable, in the circumstances, since the founder himself often is similarly vague in his ideas. But how long will the trade be content to rub along on the old lines, lacking definite knowledge on so many vital matters? Some things the founder requires to know relate to his everyday operations, such as the cause of the apparent variables in cupola operation, and how to control them, the effect of blast-pressure variation under given conditions, the best conditions of combustion for different classes of coke, the most suitable coke for different work, the best class of moulding materials for given classes of castings, the nature and suitability of different alloys, and the conditions that adversely affect the casting of such alloys. These and a host of other matters require thorough investigation by a properly constituted and representative body, so that the information—much of which is already possessed by individuals—can be made a national asset. The foundryman is every day re-

quiring some information which is available, could he only get into touch with the source.

Use of Borings in the Cupola.

At the present time, when borings and turnings are being so largely produced, most founders are more or less interested in their utilisation. The subject of melting iron borings was discussed recently before the American Foundrymen's Association, when the process of melting in cans or stove-pipe containers was advocated. (See page 592.) In the discussion which ensued Dr. Moldenke admitted that that and other methods would give good results if operated under correct melting practice, and that all of them would give bad results if the charging was bad, or the cans, briquettes or stove-pipes became damaged, and allowed loose borings to drop into the bed and before the tuyeres. He claimed, however, that for very light castings, particularly where high-speed machining was essential, no process of using cast borings would fill the bill, as the melting of material so prone to oxidation was bound to harden the metal. The mistake made in introducing both the tube and the briquetting methods into foundries had been in going to "speciality" shops machining enormous numbers of very light castings, and where the saving in the mixture was more than offset by the extra cost of machining. He further pointed out that the suggestion that the use of briquettes is unreliable is somewhat refuted by the fact that to-day there are 25 high-pressure briquetting plants in Europe in full operation and supplying hundreds of foundries with their borings in briquette form.

The author of the above-mentioned Paper referred to heats in which the loss when melting canned borings alone was less than 2 per cent. This is hardly credible, since cast-iron borings ordinarily contain nearer 85 per cent. of iron. But, apart from this point, it must be agreed that there is a distinct field for the use of borings in metal for medium and large castings, and small castings not requiring machining. So far as the experience of European founders is concerned, the briquetting process, under very high pressure, seems to have given the best results.

Steel turnings and borings, of course, are a well-known addition to cupola charges, in moderate quantities, though the loss is not recorded.

Waste Foundry Sand.

The reclaiming of waste foundry sand has often been attempted, though seldom on practical lines until recent years. Intelligently done, however, it is quite within the range of practical operations, provided it is not carried to the extreme of attempting to reclaim exceedingly fine brass-moulding sand. H. M. Lane, the American authority on sands, claims that in steel-foundry practice, where the core sand used is very similar to the moulding sand, it can always be cleaned to advantage. Experiments which he conducted convinced him that at least 80 per cent. of all waste sand material sent out of the ordinary foundry can be recovered for re-use in some form. In the case of heavy grey-iron work it can be dry cleaned, rebonded with proper kind of clay, and used as heavy-work moulding sand. In the case of aluminium and brass work the general run of sand from the foundry can be cleaned and used in core work with resin or water-soluble binders. It, however, does not work well with oil. For the thorough cleaning of certain classes of sand, the wet process seems to be the best, but this necessitates first a scrubbing and then a washing, and takes quite a complicated plant, though the actual cost of cleaning per ton is low.

Working Hours in Munition Factories.

A new General Order has been issued by the Home Office which to some extent modifies the conditions in regard to the employment of women and young people engaged in a factory or workshop of which 75 per cent., or more, of the output is on behalf of the Crown. In consultation with the Ministry of Munitions, the Admiralty, and the War Office, the Home Secretary has for some time had under consideration the question of the hours of work of women (18 years of age and over) and young persons (boys and girls under 18) in the light of the conclusions arrived at by the Committee on the Health of Munition Workers. The Committee advised that in order to maintain the health and efficiency of the munition workers unimpaired, and secure the maximum output over a considerable period of time, the hours of work should not exceed certain specified limits. After careful consideration it has been decided that effect must be given to the main recommendation of the Committee in this respect as soon as possible.

The Order applies to all munition factories, including controlled establishments. The conditions regulating four schemes of employment are set forth in the Order which has been sent to firms concerned. Scheme A allows the employment of women, girls of 16 and over, and boys of 14 and over, in a system of three shifts per day, none of which may exceed ten hours. A weekly rest period of at least 24 hours must be allowed, or alternatively a rest period of correspondingly greater length every two or three weeks. Scheme B allows the employment of women and boys over 16 on a system of double shifts (*e.g.*, two 11 or 12-hour shifts) for six turns a week, but no woman must be employed more than 60 and no boy over 16 more than 63 hours a week, excluding meal times. Unless relief workers are employed work must be stopped for two turns weekly—*i.e.*, one day turn and one night turn.

A third scheme bears on the rearrangement of statutory hours, and applies to all women and girls over 16 years, and boys over 14 years employed during the day only.

Non-Ferrous Metal Inquiry.

The President of the Board of Trade has appointed Sir Gerard Albert Muntz, Bart. (chairman), Mr. Cecil Lindsay Budd, Mr. Clive Cookson, Mr. Charles William Fielding, Lieutenant-Colonel A. J. Foster, Mr. Andrew Wilson Tait, and Mr. Alfred Harold Wiggin, J.P., to a Committee to consider the position after the war, especially in relation to international competition, of the lead, copper, tin, and such other of the non-ferrous metal trades as may be referred to the Committee, and to report what measures, if any, are necessary or desirable in order to safeguard that position.

The secretary of the Committee is Mr. James F. Ronca, to whom all communications relating to the Committee should be addressed at 7, Whitehall Gardens, S.W.

Sir Gerard Muntz is a former president of the Institute of Metals and a director of Muntz's Metal Company, Limited, Birmingham, of which Mr. A. H. Wiggin is chairman, the latter gentleman being also a director of Henry Wiggin & Company, Limited, Birmingham, and the Midland Railway Company. Mr. Budd is on the directorate of Blythe River Iron Mines, Limited (London Board), and the Eastern Smelting Company, Limited; Mr. Cookson on that of Cookson & Company, Limited, lead, copper and antimony smelters and refiners, Newcastle-on-Tyne; and Lieutenant-Colonel Foster, of Hexham, on the Northern Corporation, Limited, while Mr. Fielding is chairman of the Rio Tinto Company, Limited. Mr. A. W. Tait is a member of the firm of George A. Touche & Company, chartered accountants, of London, and is a director of no fewer than fifteen companies, occupying the position of chairman of seven of them, including the Otis Steel Company, Limited, the British Aluminium Company, Limited, Ferranti, Limited, and Fraser & Chalmers, Limited.

A Moulding Shop in the Eighteenth Century.—II.

By Joseph Horner.

Fig. 3 represents the interior of the shop lying in front of the furnace, and a part of the interior of the shed where the moulding in sand is done. The woodwork that carries the roof of the building is sustained on corbels formed on the angles

Fig. 3.

or pillars, S and T, of the base of the furnace, and on the opposite wall. At the left are the two drying troughs. Y is one of the doors of the shop.

On the right of this figure is shown a moulder ramming sand around a pattern of a pot contained in the moulding box, carried on a plate or board, the bottom side of which is strengthened by two battens. The board is placed on the bench, the length of which is about 12 ft., and the width 4 ft., and its height above the floor is about 18 ins. These benches are enclosed around three sides to the height of about 1 ft. to prevent the sand from falling off them. This is seen broken off in the foreground.

The sand, it is stated, required to be sharp and close to give a smooth surface and to sustain the weight of the metal, and had to be moistened slightly. These qualities were tested by strong pressure in the hand.

In the rear on the right is shown another moulder with a strickle striking off the superfluous sand which has been rammed and filled to the level of the box.

On the left of the illustration is a moulder who has charge of some finished moulds. He is handling 50-lb. weights or other masses of iron for preventing the two parts of the mould from separating during pouring. At the rear is seen a moulder bedding in the plate or chimney back alongside the pig mould Y, L, that furnishes the metal also for the chimney back, and which passes thereto through the runner. (This back was shown in open sand in Fig. 1 in the preceding article). A further workman is shown burying the pot moulds described previously, in front of the furnace level with the sand floor. On the trestle in the foreground the pots when cast were hung by their interiors to be fettled.

Fig. 4 represents the interior of the shop directly in front of the furnace. In the rear at the right are the drying vessels, with the drying grids suspended above. S, T are the front walls of the furnace or those on the side of the trompe.

The casting of the uncovered moulds (open sand) in the sand in front of the furnace, as chimney backs, fire dogs, and pieces, was, we are told, not at all difficult. Having pierced the furnace and let free the iron that it contained into the pig mould, it was directed thence to the moulds through the particular runners that communicated between the pig moulds and the different moulds of the

Fig. 4.

pieces to be cast. These runners were closed when the moulds had received their required quantity of iron. Coal dust was then thrown on the surfaces to protect the castings from contact with the air.

The foregoing relates to work in open sand, but

for filling the closed moulds made in loam or in sand, there were three ways, for small or medium, larger, and very large moulds respectively. If the moulds were of small or medium capacity, that is to say, if only one small ladle of iron sufficed to fill the mould, one workman only with the aid of a boy sufficed to pour it.

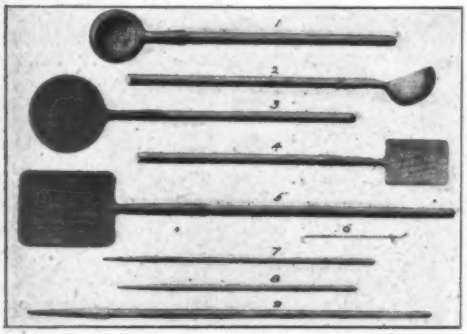


FIG. 5.

At the rear in Fig. 4 is seen a workman with the small ladle ("oueillere," or "poche") taking the iron by the top of the dam. During the operation of tapping, the bellows were stopped, and the tuyere plugged. The workman who holds the ladle has his arm which is on the side of the fire protected from the heat with a sleeve of woven stuff, which partly

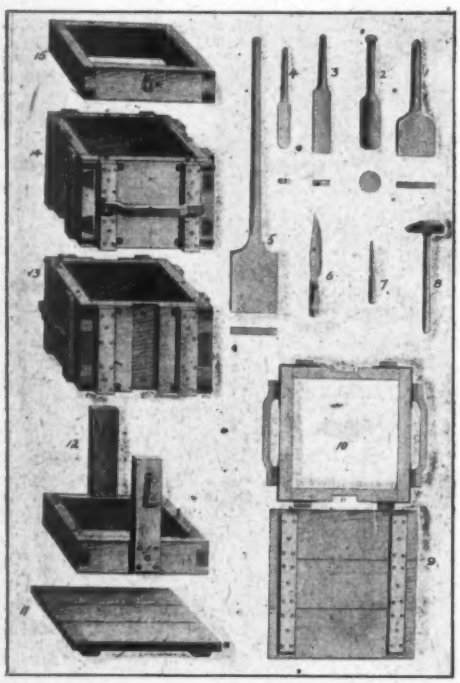


FIG. 6.

envelops the hand. On the left of the illustration is the workman who carries the ladle containing about 50 lb. of iron to the mould formed in the box. The boy helper is seen skimming back the dirt and slag from the metal in the ladle. In the centre of the illustration is shown the casting of pieces of considerable size. Then it is necessary to have two, three, or four ladles of iron. One man is seen filling the mould, and one or two others come and go alternately between the work and the furnace, and empty the contents of their ladles into the ladle of the first man. A skimmer boy is shown here also.

When the pieces were of large dimensions the metal was run to the mould without interruption. The mould was buried in the sand in front of the furnace, with the runners and vents outside or above the level of the sand. A tapping hole was then pierced in the furnace with a rod, and the iron ran to the mould. When the latter was filled the stream was turned into another mould if the furnace contained enough iron to fill it. Or else the metal was sent into the pig mould. On the right in the foreground is a workman occupied in breaking the cope from a pipe, or fettling, with a tool having a kind of double chisel formation.

Fig. 5 shows various tools. No. 1 is a ladle, about 7 or 8 in. in diam., and 4 in. deep, lined with clay. No. 2 is the same shown in profile. No. 3 is a special spade about 12 in. diam. for placing across the channel Y from the furnace, to skim back the dirt and slag. When the moulds were filled the furnace was plugged, and the spade was used to make a barrier of sand in front of the tapping hole. No. 4 is a shovel for digging holes in the sand floor to receive moulds. No. 5 is a large shovel for lifting the slag; No. 6 a hook for opening the tuyere; No. 7 is a rod, 8 ft. long, for piercing the tuyere, and No. 8 is another. Fig. 9 is a large lever for lifting pigs, or large moulds or castings.

Fig. 6 shows the tools and appliances for moulding in sand in boxes. No. 1 is a square rammer of wood, No. 2 is a round rammer with a pestle-like handle—a pegging rammer. No. 3 is a paring or trimming rammer, used for trimming different parts of moulds. No. 4 is a small rammer, and No. 5 is a large long-handled rammer used for ramming the sides of the box. No. 6 is a paring knife, used for cutting the sand, runners, risers, and enlarging openings. Runner pin patterns do not seem to have been employed. No. 7 is a gouge used for removing sand that has got into holes in the boxes; No. 8 is a hammer or mallet.

No. 9 is a mould board of pine viewed on the under side, showing the two battens. No. 10 shows the body of a moulding box. The handles by which it is carried and turned over are shown; C, D are the slides or recesses which receive the spigot pieces or tongues on the top box. The other parts, Nos. 11 to 15, are the different parts of a box complete, represented in perspective, and placed one above the other in correct order, No. 11 being the bottom board seen on its top face.

AMERICAN FOUNDRYMEN'S ASSOCIATION.—The following figures of membership are taken from the secretary-treasurer's report :—

	July 31, 1916.	
Active members, good standing	784	
Active members delinquent	24	
Active members carried on books		808
Associate members, good standing	118	
Associate members delinquent	32	
Associate members carried on books		150
Honorary members		16
Total book membership		974
Total membership paid to July 1, 1916 ..	918	
Total membership, July 31, 1915	973	
Loss for year, 6 per cent. or	55	
Resignations during year	20	
Dropped for non-payment of dues	15	

The new members received during year 1915-1916 numbered 50, of which 42 were active and 8 associate.

Gating Non-Ferrous Metal Castings.*

By Russell R. Clarke.

Gates may be placed in a three-fold classification; those leading to, those leading from and those coursing independent of the mould. Briefly they might be termed gates of ingress, of egress and of independent lead.

The term *gate*, as commonly used, is broad and general. For distinguishing purposes individual terms such as sprue, head, riser, etc., frequently are applied, though the tendency is neither universal in scope nor uniform in term selection. To avoid present confusion, this discusson will adhere to the general term and use qualifying words to designate the particular gate or part of gate referred to. The following gates may be briefly defined :—

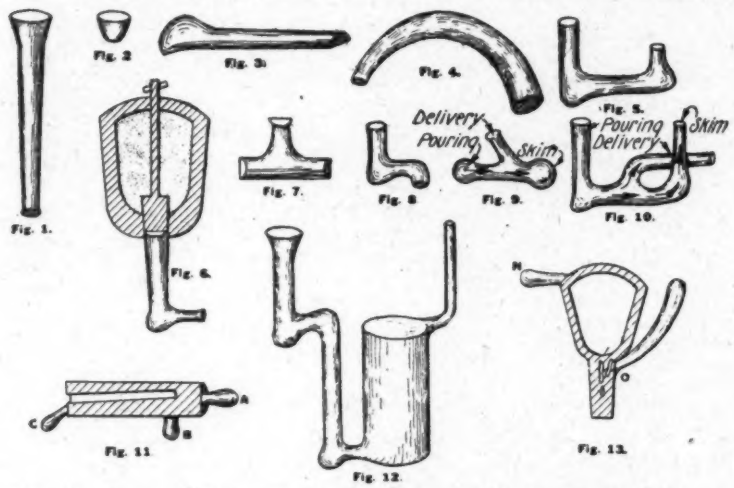


FIG. 1.—POURING GATE. FIG. 2.—BUTTON GATE. FIG. 3.—RUNNER GATE. FIG. 4.—HORN GATE. FIG. 5.—U-GATE. FIG. 6.—DROP-POURING GATE. FIG. 7.—HORIZONTAL DELIVERY GATE. FIG. 8.—CONNECTING GATE. FIG. 9.—SKIM GATE. FIG. 10.—SKIM GATE MADE BY A CORE. FIG. 11.—*A* BURNS THE CORE-END; *B* DISPLACES AND BURNS; *C* STRIKES AT AN ANGLE AND AT POINT OF MAXIMUM CORE SUPPORT. FIG. 12.—A 6 x 14-IN. BRASS PIN, GATED AND POURED FROM THE BOTTOM. FIG. 13.—*N* INDUCES A DRAW IN THE HEAVY LOWER SECTION WHICH THE HORN GATE OVERCOMES.

Pouring Gate.—Vertical ingress gate descending the mould to the first abrupt change of direction and including a funnel-shaped top.

Pressure Gate.—Section of pouring gate above the highest point of the mould metal.

Drop Gate.—Vertical ingress gate used to *step* metal downward.

Button Gate.—Bowl-shaped basin underlying vertical gate to protect sand against the impact of the falling metal—a shock absorber.

Connecting Gate.—Horizontal gate joining the bottom of one vertical gate to the top of another.

Delivery Gate.—Mould-attaching ingress gate.

Runner Gate.—Main intermediate between vertical and delivery gates.

Riser Gate.—Vertical egress gate, designed to pass off surface metal dross and relieve the mould of sudden applications of force generated by the pressure gate and intensified by momentum of metal.

Skim Gate.—Either egress or gate of independent lead, mechanically constructed and positioned to trap dirt and dross and exempt mould metal therefrom.

Feed Gate.—Ingress gate, affording some part of the mould a higher temperature or greater bulk of metal than that reaching it through regular channels.

Horn Gate.—Gate resembling a horn. A sand-hole delivery gate leading to some advantageous point in the mould not otherwise accessible.

U-Gate. — Modified form of horn-gate obtained through the use of dry-sand cores and sub-surface in position.

Drop-pouring Gate. —Means of getting metal into a mould with maximum speed and cleanliness. The plan of enlarging gate head cavity to hold all metal required to fill mould and gates, fitting a stopper core in the bottom of the cavity, filling cavity with metal and suddenly lifting the core.

Bottom Gate. — Delivery gate attached at or near the bottom of the mould.

Pop Gate.— Vertical gate attached direct to the casting. Mainly illogical in non-ferrous practice.

Flow-Off Gate.— Egress gate permitting excess metal to course through a mould or some part of a mould for some specific purpose.

Overflow Gate.—One taking care of excess metal furnished by a flow-off gate that terminates in the atmosphere.

There is scarcely a class of non-ferrous work, light, medium or heavy, in foundry practice to-day that cannot be gated to the scrap pile. Gate a 1½ by 12-in. round brass pin in the middle (longitudinally) and the highly probable result is a draw in the casting; transfer the same gate to the end and the chances favour a good casting. The author found at least 30 per cent. of casting defects identified in some way or other with the gate.

An example from experience is as follows :—A foundry took an order for a large number of valve bodies under specifications on phyiscal property covering a high pressure test; 88-10-2, manufactured from high-grade raw materials, was the alloy decided on. The patterns were made and plate-mounted for machine moulding. The castings failed utterly under the test. Every related detail in practice was gone over thoroughly and corrective measures instituted in all except the

* Read before the American Foundrymen's Association, September, 1916.

gating, to no substantial improvement. Finally, it was decided to alter the method of gating. The change had to do chiefly with delivery gate position, and though necessitating the remounting of the plate, resulted in the minimum of subsequent casting failures under test. A further example may be cited. The steam or forcing nozzle of a locomotive injector is a chunky, solid casting, weighing about three pounds and resembling a short section of tapering pin brass with a heavy knob on the heavy end, the heavy knob admitting

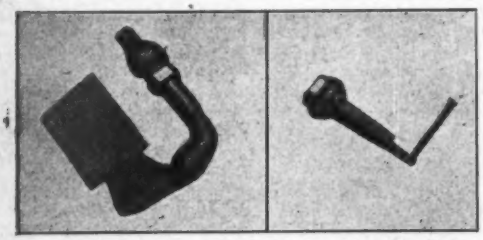


FIG. 14.—EFFICIENCY OF DROP-POURING. A THIN DISC AND A HEAVY BODY RUN TOGETHER, PERFECT CASTINGS RESULTING THEREFROM.

FIG. 15.—THE LEAD PENCIL IS AS LOGICAL AS THE SAW LOG, THE CASTING BEING PERFECTLY SOLID.

a hexagon-shaped boss on the knob's extreme end. A mounted plate with gates attached to the hexagon end produced castings with gate pin-holes terminating in spacious cavities in the metal vitals of the knob. A smaller gate attached to the smaller end of the casting eliminated the difficulty and yielded perfectly clean and solid castings.

The principles of good gating practice involve hydrostatics, expansion and contraction, radiation

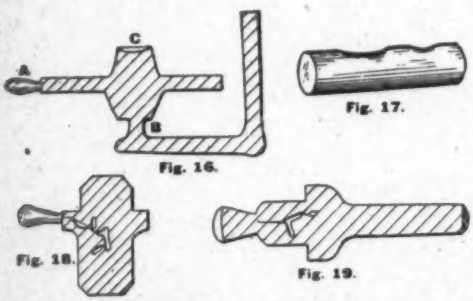


Fig. 16.

Fig. 17.

Fig. 18.

Fig. 19.

FIG. 16.—*A* GIVES SHRINKAGE AT *C*, *B* PREVENTS IT. FIG. 17.—A 3 x 12-IN. PIN, GATED AND POURED IN HORIZONTAL POSITION. END GATING AND POURING IS THE ONLY WAY. FIG. 18.—CHUNKY CASTINGS, LARGE AND SMALL, REQUIRE GATES OF VOLUME. FIG. 19.—VARIATION IN BULK HAS MUCH TO DO WITH LOCALISED CONTRACTION. OPPOSITE ENDS OF SPINDLE IS PROPER GATE-ATTACHING POSITION.

and gravity as affecting falling bodies. Hydrostatics observe three primary principles, i.e., common level, pressure transmission and incompressibility. Liquid metal seeks common level in gate and mould, transmits free and undiminished its own weight, and practically does not compress under that or any other pressure applied. By incompressibility the metal in the mould is guaranteed full gate pressure. Liquid columns of equal height generate the same pressure utterly independent of their volumes. Contraction and expansion are all but irresistible forces; they vary with volume, operate with different degrees of intensity on different elements and are most dangerous to castings at or near the freezing point of the metal. Gravity has to do with velocity and momentum of falling metal, both of which increase with time of descent. In practice, it is concerned with drop-gate partition and the construction and position of button gates.

Common level plus pressure transmission drive the metal rapidly through the gates and into the castings. Pressure suddenly applied to a filled mould strains the casting. That is an effect of gravity. A riser gate turns gravity against gravity, absorbs the shock and saves the casting. Best moulding practice is always requisite to assured results. If the sand surrounding the gate should be too dry or weak in body, it will wash away; if too wet or strong, cutting with the same casting—impairment follows. Tamped too soft, its swelling deprives the casting of pressure; too hard, cutting and scabbing again appear. Liquids transmit shock as well as pressure; a "knocking" or boiling in the funnel of the pouring-gate is transmitted to the mould, inducing unrest and endangering the casting.

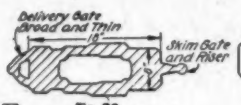


Fig. 20.

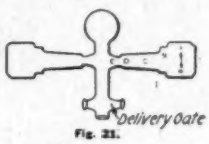


Fig. 21.

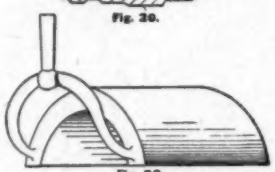


Fig. 22.

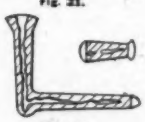


Fig. 23.

FIG. 20.—METHOD OF GATING THIN WORK.
FIG. 21.—CORRECT FORM OF RUNNER AND DELIVERY GATE.
FIG. 22.—CORRECT PRACTICE IN DOUBLE GATING.
FIG. 23.—GATES PERMITTING SHRINKAGE CAVITIES TO RUN THE ENTIRE GATE LENGTH OR WHICH TERMINATE CLOSE TO THE CASTING ARE ALWAYS DANGEROUS.

A leak between successive sections of an added pressure gate always involves a diminution of mould pressure. A purpose of the button gate is to absorb shock of impact from falling metal; it must be consistently soft, not only in the surface but gradually receding to its hard background of sand deeper down. Great volumes of metal in rapid transit through gates, play hard on naked sand surfaces. A coating of dry plumbago, well-rubbed in, is a great protection. Pouring and drop gates of great depths permit a metal momentum at their termini beyond the resisting capacity of green-sand button-gates and dry-sand core button-gates, therefore, must be resorted to. Connecting, runner and delivery gates, slanting upwards from source to terminus, break the force of flowing metal and in bottom gating and skim gate positioning are tributary to cleanliness of mould metal. The force of an inrushing current and its impact against the green-sand cores and pockets of a mould can be broken by a consistent turn in the horizontal direction of the delivery gate.

A placid current can be obtained by *backing* the metal to a point away from the casting, thence into the casting. When conflicting conditions prevent these measures, the difficulty can often be over-

come by intercepting the force of the rushing current with a small dry-sand core positioned at the point of impact in the mould. This has been found a most successful relief to green-sand cores of shallow bushings, rings, etc.

The three most common types of delivery gates are the horizontal surface, the horn and the U-gate, the former applying to the common, ordinary classes of work in which the best gating position is easily accessible, such as horizontally-cast bushings, valve bodies, stems, pin brass, etc. The horn and the U (virtually modified forms of

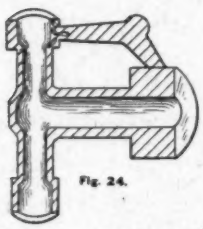


Fig. 24.

Fig. 25.

Fig. 26.

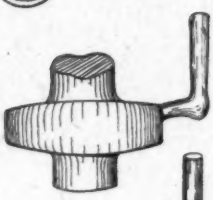


Fig. 28.

Fig. 27.

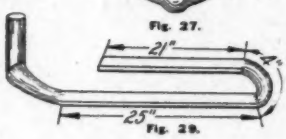


Fig. 29.

Fig. 24.—A Consequence of Double Gating under Bad Conditions.

Fig. 25.—Effect of a Direct - Attaching Riser on a Copper-Base Casting.

Fig. 26.—Effect of Slightest Variation in Bulk on Aluminium.

Fig. 27.—Gate used in Bottom - Gating and Pouring Thin Bushings.

Fig. 28.—A Shrunken Cope—a mere matter of more pressure.

Fig. 29.—Poured Horizontally and with a Single Gate, metal ran through a 1 x 1½ in. strip, straight ahead, around and up a turn inclined at 30 degrees and back 21 ins. The alloy was 85 copper, 5 lead, 5 tin and 5 zinc.

each other) apply to gating positions beyond the reach of the horizontal surface gate. Examples of their application are thin discs with heavy centres, tooth-cast gear wheels, heavy-bottom light-top classes of work, and bottom-gating in the absence of flask parting along the gating plane. The flow-off is applied to prolong fluidity and circulation of metal in a mould, as in the case of silencing a blowing core or casting copper-base metal on iron. The feed gate is attached to high and heavy positions. Bottom-gating proves its advantage in the deeper moulds whether heavy or medium, and even in the lighter class of work such as bushings cast on end. The riser gate is necessary to moulds of extensive cope area and all cases where extremely hard pouring is essential. The skim gate gives greater metal cleanliness and the drop-pouring gate takes up the task at the limit of skim-gates capacity. The drop-pouring gate also will run a thin casting which is practically impossible by most of the other ordinary methods. An example of its running capacity and the absolute purity of its casting is shown in Fig. 14, which illustrates the running of a thin disc, 1-16 in. thick and 3 by 4½ in., without the semblance of a flaw along with a valve body weighing about 4 lbs. In no part of the heaviest section and the highest point of the body was there the slightest intimation of metal impurity. The alloy used was half new, half scrap and very close to:—Copper, 86 per cent.; tin, 6 per cent.; lead, 2 per cent., and zinc, 6 per cent.

The pressure and added pressure gates force non-ferrous metals into moulds and hold them against mould-gas pressures and the recessions of contraction. To opposing shrinkage, the gate should vary in height with bulk of metal, the metal's expanding and contracting tendency, its form in the mould and its degree of fluidity in pouring.

Form and volume are most critical considerations. By the one the action of metal is controlled in the gates and its ratio of bulk to radiating surface determined; by the other, the contraction in the casting is dominated. Surfaces of all gates should be uniformly smooth to give maximum placidity in the flowing metal. For heavy and medium-bulk work ingress gates should have maximum volume and minimum surface.

The bounding surface of the cylindrical gate is less than that of any other form of equal volume. The semi-cylindrical form of gate has the advantage over the triangular or any other form equal in volume.

In the lighter and greater surface classes of work gate volume recedes in importance. No light or

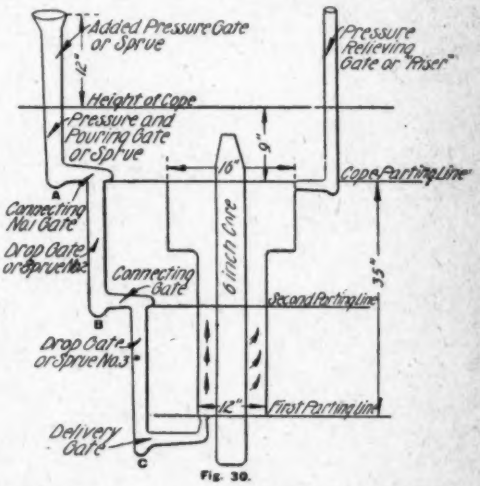


Fig. 30.

Fig. 30.—The Use of Pressure, Connecting, and Drop Gates.

thin casting should be accorded runner and delivery gates much more bulky than the casting itself.

Horn gates should have radii of curvature assuring a safe body of sand between their self-created openings and those portions of the mould they underlie. The same applies to U-gate dimensions. Button gates should represent cones diminishing downward and terminating in a circular basin. They should be cut on radii greater than the drop gate and positioned directly under it. At the immediate point of mould attachment, all gates

should enlarge to fillet effect. Metal in ingress gates is hotter than that in the mould; that in egress is colder. It follows that in the same mould their forms must necessarily differ. Cooling in advance of mould metal and bereft of any substantial pressure, the egress gate must represent a minimum of contracting tendency, necessitating reduced volume and increased surface.

In the skim gates of independent lead, the principle is to intercept a stream of metal *en route* to the mould, trap its dross into a by-path and permit the clarified metal to enter the casting. The form of gate varies. Very frequently the dry-sand core is resorted to, admitting mechanism not practical to the green. Egress skim gates are usually parts of risers and pass off mould-accumulating dross. Positioned at highest points of mould or in places to which ingress influence directs the mould current, and broad-cut to encompass sufficient mould surface, they promise best results.

The primary evil of contraction during cooling is a draw or shrinkage cavity in either gate or casting. To keep it out of the casting is a chief end in gating, which can be aided by slight and gradual reduction from source to mouth in gate volume, and ample pressure. If a delivery gate at point of union with the casting is dimensioned to its volumetric requirements at that point and every linear unit back of that point slightly larger than at that point, there can be be no chance of a solidifying metal mass in the casting drawing on an empty source of supply and no possibility of solidification at any point in gate metal preceding that in the critical zone of the casting.

Gate area at point of attachment to the casting is highly important. If excessive, every gate behind it wastes metal; if too small, it is incapable of performing its function, and shrinkage in the casting results. Volume in the casting in relation to surface, fluidity of metal at correct pouring temperature, distance from gate entrance to extreme point in the mould, pattern variation in bulk, nature of metal used—all must be taken into serious consideration. Bulky castings, large or small, require greater gate volume, regardless of apparent insignificance; a 4-in. square disc, 2 in. thick, will cast better with the same gate volume than a 3-in. cube, though the former represents 5 cub. ins. more in solid contents. Gates as large or larger than the casting are foolish. The drop gate in Fig. 15 was made by an ordinary lead pencil and ran a 2-lb. bulky casting perfectly clean and solid.

The positioning of a gate is another important consideration. As in gate volume, everything depends on conditions. Generally, castings do better gated on the end than at middle points, this applying to bushings, stems, plugs, valve bodies, pin-brass, etc. A gate attached to a heavy bulk, reducing backwards to a lighter, often produces pin holes and cavities in the heavier bulk. The heavy bulk being closer the gate is liquid longer than both lighter section and gate, being drawn on by the former and deriving no ultimate supply from the latter. Gating on to heavy sections connected with lighter ones pre-supposes a larger gate than would otherwise be the case. When bulk difference is not excessive, the better plan is to attach to the lighter section. In multiple gates attached to light castings, position and current should be so determined as to lead streams to unite in the mould *en route* through it. Unions of recoiling metal, or in streams of metal approaching each other from opposite directions are, to say the least, open to suspicion.

Bottom Method of Gating.

Wherever admissible, the bottom method of gating is the ideal for both heavy and the lighter classes of work. For purely experimental purpose the author once got a perfect casting from a ⅛ by 1¼-in. strip, 30 in. long, by pouring it in a vertical position and gating it at the bottom. In thin, cylindrical classes of work our practice is to cast upright largely, and to pour from the lowest position in the mould. The chime-whistle body is an example. In its pouring, metal winds in and around mould-congesting cores to a height of 14 ins., running accurately very thin walls and webs, and a central bushing. Primarily, the advantages of bottom gating are as follows:—

It makes the drop gate a skim gate; prevents disassociation of metal; graduates core gas formation and gives the gas free escape upwards; keeps vapour pressure ahead of the metal, and lessens its confinement in pouring; places the delivery gate at the point of maximum pressure, forcing a compact metal union; limits force and commotion of falling metal to a locality which allows freedom in construction; sweeps everything ahead of it, ensuring surface position of mould-developing dross; generates greatest background vapour pressure in that part of the mould where greatest metal pressure is present to resist it, and practically eliminates shrinkage at the point of gate attachment.

Cases have been exceedingly rare where we ever found pin holes in bottom gates. Vapour pressure generated in the drop gate sometimes sweeps the mould metal surface, causing a casting top surface depression. Free venting and safe distance will overcome the difficulty.

Expansion and Contraction.

Alloys representing varying proportions of different elements involve different degrees of expansion and contraction, and demand similar consideration in their gating. Mainly, it appears that in casting, copper and aluminium are chiefly disturbed by these two opposite tendencies; that in combination they get little relief from it; that with the addition of lead and tin intensity recedes while in the presence of zinc it again jumps into prominence. A further observation is that whatever the immunity of new material to shrinkage tendency, that immunity becomes conspicuously absent with repeated remelting. To formulate a definite comparison of shrinkage tendency between different elements and alloys in casting, a series of tests was roughly made. Dry-sand moulds were resorted to and a solid disc pattern, 4 ins. in diameter and 1⅛ in. deep, was used. Semi-circular delivery and round pouring gates were selected, the pouring gate having been ¾ ins. high and the delivery containing 7/20 cub. in. per linear inch. Half new and half scrap metal was melted in a small crucible, under best of practice, and the moulds poured, with the results in shrinkage as indicated in the accompanying table.

These results can be relied upon only in a comparative sense, for after all, the main evil of contraction in casting arises more from variation of bulk than from bulk itself. In the test, aluminium shrinkage did not show up so strong. As stated, dry-sand moulds yielded an advantage, and in casting it must be considered that aluminium is, by virtue of its low specific gravity, a green-sand-abhorring metal. For this reason sand accommodating aluminium gates should be worked as dry and bodily impoverished as conditions will permit. Personally, so long as the sand

does not fall out of the flask in manipulating, we feel satisfied. The flow-off and the pop gate are advantageous in aluminium work. The better form of pop gate is that of a common wedge, diminishing downward and attached to the casting with a very thin edge.

Summarised Conclusions.

A button on a riser is metal wasted.

The smallest gate or set of gates conducive to casting quality, are the best in non-ferrous work.

Smaller gates will answer for copper-tin-lead than those alloys including zinc along with them.

Shrinkage Noted in Tests.

Alloy.	Maximum depression, inch.	Position of depression.	Surface affected, sq. in.	Depression regular or irregular.
Copper and small per cent. of silicon ..	1/16	Central	10	Regular
Aluminum ..	1/16	Central	7	Regular
Zinc	3/32	Central	8	Regular
Tin	1/8	Beyond centre opposite gate	3	Regular
Lead	1/16	Centre	3	Regular
Cu. 90, Al. 10 ..	3/32	Centre	6	Regular
Cu. 85, Pb. 5, Sn. 5, Zn. 5 ..	1/16	Centre to outer edge opposite gate	5½	Regular
Cu. 66 ⅔ Zn. 33⅓	1/16	Centre	9	Very irregular
Cu. 80, Sn. 10, Pb. 10 ..	1/16	Opposite gate beyond centre line perpendicular to gate	3½	Regular
Cu. 88, Sn. 10, Zn. 2	3/32	Centre	4½	Irregular

A gate's capacity to perform its function varies with the degree of fluidity of the metal in pouring.

The volume of all gates tributary to it should be reckoned from the volume of the delivery gate at its point of union with the casting.

A good fillet will operate against a draw, and will prevent the in-breaking of gates removed from hot castings.

Sharp angles at turning points of gates are not conducive to best results.

A good gate-cutting moulder can cut a better and cheaper gate in the sand for mounted plate work than a pattermaker can make a pattern for. The gate thus cut can be poured, finished and attached to the plate.

Connecting gates cut above flask parting surfaces give better service than those cut below.

The top of a riser gate always should be covered in mould pouring.

Pressure is derived from height, independent of volume.

Pressure at any point in the mould equals height of gate above that point divided by 28, and multiplied by the specific gravity of metal involved.

Higher pressure is necessary for scrap than for new material.

"Touching-up" a head gate aids feeding, but yields no additional intensity of pressure.

A leak in the gate reduces pressure in the mould.

Metal sinking rapidly in a pressure gate may indicate a swelling casting.

If the shrinkage cavity in a pouring gate descends to the gate's lowest point, its extension upward or increase in its volume is requisite.

Gate pin-holes in the casting may result from hard ramming, wet sand, lack of pressure, improper construction or placing, double gating or cold metal.

All gates should observe a minimum in safe distance to or from the mould.

Green-sand gate transmission of large volumes of metal finds additional safety in properly skin-dried gates.

Double gates of unequal volume, or those attached to light and heavy casting sections respectively, induce shrinkage.

Pouring should be started in a feed gate the moment metal from the mould enters the same, otherwise the gate may freeze or its colder metal may be driven back into the casting, porosity resulting. The same applies to the double pouring of moulds.

A green-sand head or pressure gate yields best results in pouring chill-made copper-base castings.

In the drop-pouring method, pressure is applied most suddenly, and necessitates a strong mould with riser-gate relief.

Moulds containing delicately anchored cores should be so gated and poured that rising metal plays on the minimum of core surface.

A stream of metal playing throughout pouring on a given core surface, is liable to burn the core solid at the contact point.

A gate situated too close to the edge of the flask is a menace to the casting.

If a riser can be made to perform its own and skim-gate functions advantage should be taken of the fact.

The use of water in gates is bad practice.

Gating from one casting to another admits a chance of both being bad.

A single gate cut at such an angle as will direct the metal current to a circular motion in the mould answers best for ring-shaped castings.

Double gating induces drawing, sends two streams meeting at a point opposite the button gate, depositing all their dross at that point and often failing to unite properly.

Cope shrinkage usually is a consequence of cold metal and poverty of pressure. Drawing can follow the same, though it is just as likely to result from variation in bulk of metal. Both are consequential also to errors in moulding practice.

Every pressure gate should slightly and uniformly overtax its mould's-resisting power.

Heavy work delivery gates require that volume only that will satisfy the demands in the region of gate attachment.

Elevating the pouring ends of moulds of horizontal gating to aid in running the castings is a mistake. Metal runs best for casting when driven either up-hill or on the level by ample pressure behind it. It runs down-hill easier, but it does not always hang together in so doing.

Excessive hand tamping will stop a thin gate from running.

High temperature metal is most exacting on gates. Cold metal creates greater friction but forms its own protection by its surface solidification.

Very often a thin casting worked along with heavier work will do better at the extreme end of the runner gate than from a gate branching from the button gate, a matter of direct and rapid transit.

At their union therewith, the bottom surfaces of all delivery gates should approximate, though never exceed, the surface of the runner gate.

In all cases of the highly duplicated type in loose pattern work, by making sufficient patterns to fill a flask and a master gate for continuous service, great saving and efficiency can be realised.

Some Properties of Ingots.*

By A. W. and H. Brearley (Sheffield).

(*Continued from page* 527).

The Taper of Ingot Moulds.

If it is assumed that a taper ingot mould with the narrow end upwards is full of fluid metal at a uniform temperature, the act of setting may be represented by a series of equidistant lines drawn on a longitudinal section of the mould parallel to its inner surface, as in Fig. 17A, each line being made shorter than its predecessor to account for the continuous shrinkage. The point at which a pair of these lines meet within the mould may be taken as indicating that in the horizontal plane passing through it the metal has solidified completely. The cavity above the point of intersection is a pipe pure and simple, and may be distinguished as "primary pipe." But there still remains a triangle marked K, which, according to our assumption, contains fluid metal and is

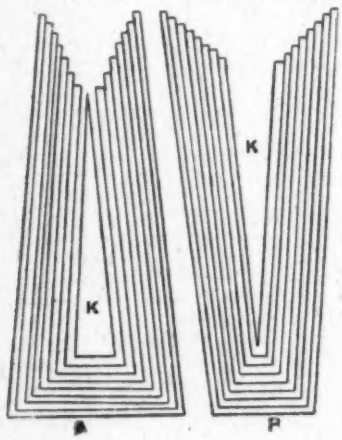


FIG. 17.—FREEZING IN TAPER MOULDS.

hermetically sealed. This fluid in due course will also shrink and freeze and contract, but there is no possibility of the cavities thus formed being fed, and there is formed thus a more or less discontinuous extension of the pipe, which may be called "secondary pipe."

On representing in the same manner the freezing of metal cast into a taper mould with the wide end up, but with shorter steps down because the shrinking fluid is falling from a wider into a narrower part, we arrive at Fig. 17 B. Here also the lines intersect and represent, similarly, that the material lying below the point of intersection has become solid. There is also a triangular residue of fluid metal, but in this latter case the triangle is inverted and the metal within it will freeze earliest at the lowest point, any shrinkage being meanwhile fed from above, and leave finally a hollow shrinkage cavity in the axis and at the upper end of the ingot. It is not possible in this kind of ingot to have a secondary pipe.

The assumptions on which Fig. 17 are based take into account neither the speed at which an ingot is cast nor the cooling effect of the air on its upper surface. Ingots are not made by filling moulds at the greatest possible speed, or when they are, the ingots are inferior ones. It may take anything from one-half to fifteen minutes to cast an ingot (depending on its size, the kind of steel from which it is made, and the temperature of the molten steel), and during that time the lower part of the ingot is cooling and the upper part of the ingot mould gets heated before the fluid steel reaches it.

The cooling effect of the air forms a cover of frozen steel of greater or less thickness over the top end of the pipe. In large ingots the thickness of this cover may be several inches; in small ingots it may not persist at all; but in either case the atmospheric cooling thickens also the metal about the upper part of the pipe. If, however, the influence of these variations be added to the hypothetical case represented by Fig. 17 it will not be modified out of all recognition, as may be seen by comparing the assumed forms with those of two small steel ingots shown in Fig. 18.

Nothing can be done to prevent the shrinking of fluid steel as it passes from the liquid to the solid state; and the only means of providing against the inconvenience of it is to arrange for fluid metal to be kept at a higher level ready and able to flow into what otherwise would be a shrinkage cavity. This means that an ingot must always solidify from the bottom upwards, which it does naturally when cast into a taper mould with the wide end up; or in general terms, the metal in any plane must solidify earlier than the metal in any higher plane if shrinkage cavities are to be avoided.

A fluid ingot cast with the wide end up shortens less rapidly than one cast with the narrow end up, and it is therefore more likely that the upper crust of frozen metal will resist the pressure of the atmosphere when the fluid underneath ceases to support it. This to some not very great extent will help to keep the upper and interior part of the steel fluid; it is more valuable, however, because it may prevent oxidation of the interior of the pipe and thus facilitate its welding when it comes later to be rolled or forged. It may also be observed that the pipe in one case takes the form of a long pointed cavity, and in the other a short cavity with rounded end (Fig. 18). Apart from the relative volumes of material thus made unsound, and likely to be scrapped, the former, occurring in ingots cast with the narrow end up, is more likely to cause ingots to clink in the reheating furnaces. These are all points of minor importance in themselves, but experience shows that they lead sometimes to grave consequences, and it is therefore worth while to note that in these minor respects the soundness and reliability of the ingot is improved by casting with the wide end up.

The disadvantage of a shrinkage cavity whose surface has been oxidised by exposure to the atmosphere is recognised no matter in what kind of steel it occurs; but it is widely believed that other kinds of shrinkage cavities will weld up without the steel being any the worse. Such a view is not quite in harmony with actual experience, and it may be said that the question is not and cannot be quite settled, as has been inferred, by boring holes into ingots or cogged bars, and then, after sealing hermetically, observing their behaviour on forging.

* Read before the Iron and Steel Institute, September, 1916.

A hole made with a drill is smooth and perfectly clean. The interior of an unoxidised shrinkage cavity is uneven, and its walls are often lined with small crystallites, which make sharp angles with each other and form very favourable starting-places for internal clinks when the ingot is reheated too rashly. On the surface of such cavities one may sometimes find a fine coating of alumina which has been floated there on the decreasing mass of mother liquid, and left high and dry as the last of the fluid falls to a lower level. It appears to be on this account that blisters raised on thin sheets during hot rolling are occasionally found to be coated on their inner surfaces by a layer of alumina of a pale yellow colour. This also has something to do with the lamination of saws and other articles either during stamping or in the subsequent hardening operation.

The central and unoxidised shrinkage cavities lying in straight-sided ingots below the feeder head were at one time during the progress of setting filled with liquid steel which fed the crystallites of purer metal growing from the walls of the cavity. But whilst the fluid metal sank downwards the crystallites remained, and when the ingot becomes a billet or bar, that part of it formed by the free-standing crystallites is purer, *i.e.*, contains less carbon and other segregating elements, than the surrounding material. This means, of course, that some part of the bar or bars will have a soft centre and cause disappointment if made into chisels or drills, or if made into accurately drilled objects, such as rifle barrels. This kind of defect is most clearly visible to the naked eye in the fracture of steels containing between 0.90 and 1.1 per cent. of carbon, but it can also be detected in lower and higher carbon steels by polishing and etching. The position of a soft centre in a steel bar is the same as that of a hard centre, and the one may occur not far behind the other. Fig. 19 is a photograph of a bar which has been split longitudinally in order to disclose the soft centre.

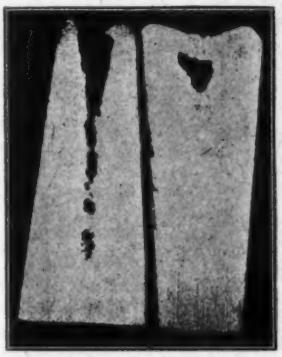


FIG. 18.—SECTIONS OF STEEL INGOTS CAST NARROW AND WIDE END UP.

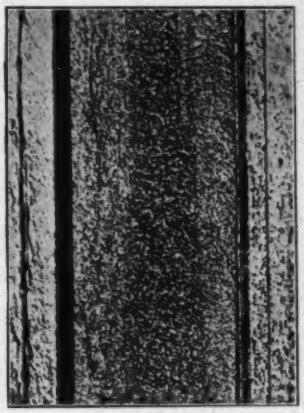


FIG. 19.—SOFT CENTRE IN COGGED BAR ARISING FROM AXIAL CAVITY IN INGOT.

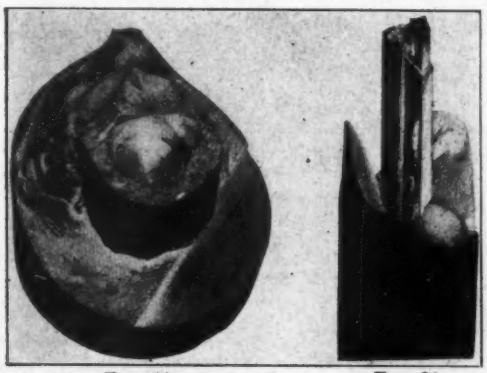


FIG. 20. FIG. 21.

DEFECTS IN STEEL BARS ARISING FROM AXIAL UNSOUNDNESS IN INGOT.

The harder the steel the more important it becomes that the ingot should be free from these axial cavities, and that not only because the danger of clinking is greater and the chances of welding up the cavities are less, but because the harder material at forging or rolling temperatures is less ductile, and under distortion the cavities may actually extend. This observation is notably verified by the behaviour of high-speed steel, and on that account ingots of high-speed steel ought always to be cast in taper moulds with the wide end up and fed by means of a white-hot sleeve or dozzle. The neglect of this precaution is one of the contributory causes to which the well-known splitting along their length of high-speed steel tools may be ascribed Figs. 20 and 21 show examples of defects in self-hard steel bars, unweldable at any temperature, which originate from cavities existing near the axis of the ingot.

The inverted taper mould is not generally used for ingots whose wider end is less than 4 in. across; the reason being that, with the usual taper, the narrower end becomes too small to be struck directly by the molten stream without fear of its having previously impinged on the side of the mould. When a stream of molten steel strikes the side of the mould the ingots are said to be "catched." A catched ingot is regarded as objectionable because it scars the surface of the ingot and may lead either to a lamination, akin to a lap, or a roak on the surface of the bar. On the surface of very hard steel, notably on self-hard steel ingots, a "catch" may lead to deep transverse cracks in the forged bar.

In many cases part of the fluid steel which strikes the side of the ingot mould adheres to it, and is not only solidified but comparatively cold before the steel rising in the mould reaches up to and covers it. The cold strip of steel then adheres to and becomes part of the ingot, and may be regarded as an inlaid strip of metal whose inner surface is more or less in contact with the ingot. The strip, however, never melts, and its temperature does not become equal to that part of the ingot in which it lies. As therefore the ingot shortens in length by contraction, the strip, unless it contracted at the same rate, which owing to variation in temperature it does not, will locally resist the ingot's contraction, and small cracks in the ingot may be formed underneath or about the strip. What happens is really a pull on a small scale, but the hardly discernable cracks on the ingot develop into obvious cracks in the bar forged from it.

It may also be observed that the material imme-

diately beneath a catch is spongy. The sponginess is caused by oxidation of the surfaces of the strip of steel before the metal rising in the ingot mould covers it. The oxide film reacts with the carbon of the fluid metal, as soon as the two come into contact, and small quantities of carbon monoxide or dioxide gases are liberated just as though that part of the ingot mould were rusted.

Sound Ingots.

Sir Robert Hadfield* has already extensively studied the question of producing sound steel, and has drawn attention to the importance of obtaining sound ingots. One speaks of sound ingots in a comparative sense. Absolute soundness is never attained, but the imperfections which give rise to no blemish or defect in the intermediate or final stages of manufacture are disregarded; and if they are also equally unobjectionable in the use of the article they are commercially negligible. It may happen, however, that apparent trifles arising in the course of manufacture grow into serious defects or causes of defects in service, and to trace their origin and fix the responsibility becomes a lengthy and delicate matter. If, therefore, an ingot works up into apparently faultless plates and bars and general forgings, it does not follow that the ingot was a sound one, but only that any unsoundness present was of small obvious consequence.

Thousands of tons of ingots known definitely to be unsound in the absolute sense are rolled into girders, plates, rails and other forms, and appear to yield no worse service on that account. Some others break and involve loss of life and other misfortunes as a set-off to the lower costs of manufacture arising from the use of material which is thought to be good enough, but not so good as it could possibly be made. In producing steel at what is called "the market price," these "insignificant" defects in ingots are made as harmless as possible. In respect to piping and shrinkage cavities this is accomplished by cropping the top end of an ingot, or by avoiding oxidation of the surfaces of the cavities in order to increase their chances of welding up. To a certain extent this latter aim is secured by bottom-casting, but direct attempts to secure its success have been made in other ways, *e.g.*, inverting the partly solidified ingot.

Individual steelmakers are to be found who contend that bottom-cast ingots can be made perfectly sound in the usual mould by using a long trumpet and feeding it with hot metal. This, on the face of it, is highly improbable, however long the trumpet is made, as the steel in some parts of the runner brick will certainly freeze across, and thus hermetically seal up the ingot before the interior parts of the ingot have solidified. As to volume of shrinkage cavity, there is not a great deal to choose between a bottom-cast and top-cast ingot which have been poured at the same rate; the advantage enjoyed by the former is that its cavities are likely to be sealed from atmospheric oxidation.

If the feeding of a bottom-cast ingot through the trumpet be left out of account and we imagine the mould to have been instantly filled with fluid metal, then it does not matter whether the filling took place from the top or the bottom. The position and size of the shrinkage cavity would be the same in either case, except that with a closed top mould a thicker upper crust would form and there would be small chances of bridges forming beneath it. The first advantage then of bottom-cast ingots is that shrinkage cavities are more likely to be clean and weld up.

The metal rises in the mould more slowly on bottom-casting both on account of the mass of grouped ingots and also because each mould is filled against the pressure of the column of metal in it. The steel freezes through contact with the mould whilst it is being cast, and at the end of the casting period the solid shell would be thicker, if bled, than the shell of a top-cast ingot of the same size; this is all to the good so far as volume of shrinkage is concerned. Moreover, the ingot is fed under pressure by metal from the trumpet so long as the runner bricks remain open, and this again lessens the volume of shrinkage cavity.

As steel rises slowly in the mould, beyond the disturbing influence of the incoming stream, it heats up the sides of the mould and becomes itself colder, so that when the mould is full and the trumpet pressure can avail nothing, the freezing of the ingot is completed downwards from the narrower top end containing colder metal to the wider bottom end containing hotter metal. The ingot therefore may have two infected areas; one at the top occupied by a pipe, and one in the lower third of the ingot occupied by spongy metal.

The slower rate at which grouped ingots are cast is an advantage so long as the rate of casting is not too slow. Under normal circumstances the rate will be determined by the number of moulds to be filled through one runner, their cross sectional area, the height of the trumpet, the amount of metal coming through the ladle nozzle, and the area of the passages in the runner bricks. To these must be added the temperature of the steel and its freezing point.

The clean skin expected on ingots cast from the bottom is not always realised. When cast too slowly the ingots are folded on the surface, as indicated in Fig. 12, and when steel is run down the trumpet too quickly to begin with it rises like a fountain through the bottom and splashes the sides of the moulds. When cast at average speed the molten metal runs rather sluggishly to begin with along the cold runner bricks, and when first sighted, at the bottom of the mould, appears as a nodule of pasty metal. By pressure from the increasing head of fluid in the trumpet pipe the nodule is forced out of the hole and the metal enters more or less quietly.

As the area of the opening in the trumpet pipe is less than that of the combined openings in the runner bricks, the steel having once properly entered the moulds feeds quietly into them. Later, however, a head of metal must form in the trumpet to overcome the fluid pressure inside the moulds and break through any crust forming on the upper surface of the ingots. The heavy fluid thus pressed through a circular opening is expected to travel up the axis of the ingot mould and diffuse itself into the surrounding metal as it rises; there is reason, however, to believe that it often acts otherwise. The thickness of the runner brick, where the vertical opening is made, is approximately half an inch. Even if this opening were made and set mathematically true, the stream would not make headway vertically through the moving mass of metal; it would be diverted first to one side and then the other by uncontrollable incidents.

But runner bricks are made and laid in the casting plate by human agencies; and sometimes the opening is sloped and sometimes it

* *Journal of the Iron and Steel Institute*, 1912, No. II., pp. 11 40; 1915, No. 1., p. 40.

is chipped or has a fash on one side. Either incident will cause the metal delivered under pressure to be diverted from the vertical, and that part of the mould in direct line with the sloped opening in the runner bricks will be washed by the incoming steel, and may have a cavity melted out of it. This is represented diagrammatically in Fig. 22.

The mould is attacked in this manner at varying heights, sometimes as much as 16 in. from its base. If the opening lies centrally under the mould the steelmaker may hesitate to believe that the cavity when disclosed can have arisen from any defect in the casting arrangement. It is much easier for him to think that the mould as delivered by the ironfounder contained such a defect more or less consciously concealed, and the view seems to be justified by the fact that troubles of this kind arise more frequently in new than in old moulds. The reason, however, for this apparent justification, apart from the fact that new moulds are more carefully scrutinised, lies in a difference between new and old moulds, the inner surfaces of the latter being protected to some extent by the deposit of oxidised metal which thickens on them by use.

Deflection of hot metal to one side of the mould favours the formation of cracked ingots. This remark ought to be decorated like a recurring decimal when applied to the casting of hard steel ingots. If the runner brick does not open in the axis of the mould the incoming streams cannot possibly form an ingot whose temperature is uniform, and the chances of the surface of the mould being cut are increased. If the mould rests cornerwise on the runner brick, so that the stream

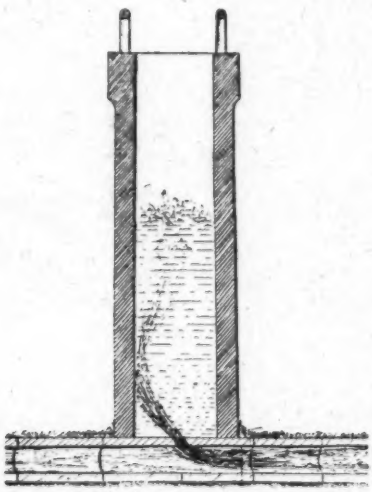


FIG. 22.—EFFECT OF SLOPED OPENING IN RUNNER BRICK.

of metal before entering the mould runs along a diagonal of the ingot, which owing to bad design of the bottom plate or considerations of space may occur, then the corner of the ingot to which the moving stream is directed is very apt to crack; and if not cracked on that corner the ingot will certainly not be cracked on any other. In such cases cracks are to be found only in the lower parts of the ingot; higher up the force of the stream is dissipated as the head of metal increases.

The most advantageous arrangement, within the authors' experience, for casting groups of ingots is a solid-bottom mould having a central hole provided with a small taper fireclay sleeve as shown in Fig. 23. This arrangement ensures the formation and feeding of the ingot by a stream of fluid steel entering on and passing up the axis of the mould. The fireclay sleeve is also long enough to give direction to the incoming fluid, and both damaged ingot moulds and longitudinal cracks in ingots are practically eliminated. When cast in this manner the mould must necessarily stand with the wide end uppermost.

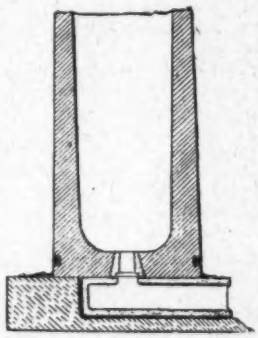


FIG. 23.—DETAIL OF MOULD FOR BOTTOM CASTING.

If we assume a mould to be full of fluid steel at a uniform temperature, then the solid ingot could be sound only if it had been cast with its wide end uppermost. But in all top-cast ingots the fluid occupying the lower part of the mould is colder at the moment casting is finished than is the metal occupying the upper part of the mould, and this to a certain extent, depending on the dimensions of the ingot and the speed of casting, is favourable to sound ingots independent of the direction of taper of the mould. Also the quantitative effect of a taper of, say, 1 in. to the foot is not the same on the freezing of a large as of a small ingot. In a small crucible mould, for example, the area of transverse sections a foot apart might be in the proportion of 4^2 to 5^2 and in a larger ingot in the proportion of 20^2 to 21^2; but in the latter case the speed of casting would naturally be more favourable to the production of sound ingots than in the former if both were top-cast. For these and similar reasons it is not permissible to apply rigidly the results of observations made on small ingots with ample taper to much larger ingots cast with so small a taper that they can be stripped only with a machine. Much variation of opinion and a great deal of the recent controversy about sound ingots arise from neglect of this important difference. The difference, however, is one of detail, not one of principle, and the inverted mould should be adopted as the safest means of securing freezing of the ingot from the bottom upwards whatever may be the size of the ingot.

As a means of feeding the unavoidable shrinkage cavities in the upper part of an ingot, the simplest and most effective device is the white-hot fireclay head or dozzle used by the crucible steelmaker. No feeder-head and no system of producing really sound ingots involves so small a percentage of waste. But the device has not been applied to very large ingots, nor to groups of ingots cast through the bottom from a common runner. A refractory head in the form of a brick lining in the upper part of the mould or, more economically in some cases, as a superimposed piece, can be operated with a discard of 10 to 15 per cent. of unsound and segregated material.

Apart from shrinkage cavities the inverted mould is advantageous in another important

respect. When steel is cast on the cold side, as certain kinds should be to facilitate cogging in the forge or mill without cracking, there forms on the upper surface of the fluid steel a crust of crystals which, as previously explained, may be broken and thrown back on to the sides of the mould, or pieces thereof may be washed into the ingot and form blowholes and other centres of weakness. In the ordinary form of mould this frozen surface is being pushed, as the steel rises, into a constantly decreasing area, and it must ultimately break up or allow the steel to flow over it. In the inverted mould, on the other hand, the frozen crust is rising always into a larger area, which keeps its edges free and permits it to grow without becoming thicker and stronger; consequently there is less danger of the crust being broken, and it is possible to produce groups of ingots at a lower casting temperature.

The principles of ingot-making already briefly described are applied in what follows to a few of the problems arising in ordinary works practice. One of the most difficult of these is segregation and the occurrence of ghost lines in large ingots.

If an ingot can be made to consist entirely of long narrow crystals as indicated in Fig. 1, the segregates are crowded into the centre and towards the top of the ingot. But a large ingot could not be made to consist entirely of such crystals, and somewhere between the outside and centre of a cross section there is a more or less clearly defined boundary between crystals growing inwards from the outer shell of solid steel, owing to heat conduction, and crystals deposited from the mother liquid whose temperature has fallen to freezing point This boundary line can often be seen on a well-made sulphur print of common steel.

The chill* crystals, which extend inwards from the already solidified shell, form a compact mass. They grow into close contact with each other, pressing the less pure and more fluid material from between their faces and confining it within a receptacle which becomes continuously narrowed. When the temperature of the fluid metal within this receptacle falls to freezing point then "free" metallic crystals form and sink towards the bottom or adhere to the inner surface of the solid walls; and such crystals lie loosely together like thistledown and allow the liquid metal to pass between them.

Talbot has shown,† and Neu also at an earlier date, that when the sides of a partially solidified ingot are squeezed together to form a rough bloom, the cross section of such a bloom shows purer material in the centre and outside than on a median area. The area which is thus found to be occupied by the segregate corresponds to the boundary between the "chill" crystals and the "free" crystals; or more correctly, it should be said that the outer edge of the segregated area cannot lie nearer the face of the ingot than the said boundary line, the reason being that the fluid squeezed from the interior can penetrate the solidified wall only until it reaches the more compact chill crystals. The purer interior of such blooms consists of the free crystals already formed in the fluid ingot metal and suspended therein or attached to the walls.

If, therefore, it were thought desirable to move the segregates in a Talbot ingot towards the centre, it could be done by increasing the chilling effect of the mould and raising the casting temperature, *i.e.*, by increasing the thickness of the solid shell before the fluid it contained had reached a temperature at which crystals began to form freely within it.

By reasoning along similar lines we observe that in very large ingots (such, for example, as are used in making gun tubes) the wall of compact crystals starting from the interior of the mould drives before it, as it thickens, a fluid envelope of impure metal which diffuses readily with the hotter metal nearer the centre as long as both remain quite liquid. When this interior liquid reaches the upper limit of its freezing temperature, the more flocculent kind of crystal begins to adhere to the compact walls, and thus restrains somewhat the free movement of the liquid segregate which at that moment occupies the same position. Unless we are prepared to assume a somewhat violent movement of the interior liquid, it must happen that the segregated fluid becomes

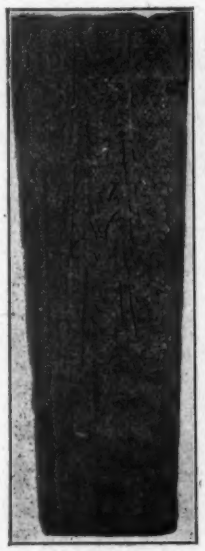


FIG. 24.—BEARDMORE SULPHUR PRINT (REDUCED) SHOWING POSITIONS OF GHOSTS.

FIG. 25.—SHOWING DISPLACEMENT OF GHOST LINES ACCORDING TO RATE OF FREEZING (SULPHUR PRINT BY ASHDOWN.)

imprisoned and solidified where the two kinds of crystals meet, and as a matter of fact it is from that position inwards that ghosts are found. As a natural sequence one would expect to find the lower part of an ingot, which receives most of the deposited free crystals, to be either altogether or relatively free from ghosts. Also it might be predicted that a line drawn on a longitudinal section parallel to the side of an ingot would cut simultaneously the outer ends of a number of ghost lines.

By the kindness of Sir William Beardmore the authors are able to exhibit the sulphur print of an ingot clearly illustrating segregates or ghosts of the kind referred to (see Fig. 24). The explanation given may be confirmed both deductively and by

* For the sake of brevity those crystals which form at the inner surface of the mould and grow into the liquid steel are called "chill" crystals; and those which form unattached in the cooler fluid and tend to fall on to the bottom or sides of the solid shell are called "free" crystals

† *Journal of the Iron and Steel Institute*, 1913, No I.

actual observation, but before applying these methods it should be said that the maker of gun tubes first trepans a core from the centre of the ingot or from the centre of a large billet made from the ingot. He does not care very much whether the discarded core contains ghosts or not, but it is very important commercially to have no ghosts, or as few as possible, on that part of the ingot which will lie ultimately near the bore of the gun.

(A.) In a large ingot cast in a loam mould the ghosts were found to be distributed almost to its edge, and it was not possible from any part of the tube to secure test-pieces which would pass inspection. This condition arose obviously from the fact that circumstances were unfavourable to the formation of chill crystals.

(B.) As the result of extensive experiment it has been affirmed that much better results are obtained, *i.e.*, there is less trouble with transverse test-pieces cut from a gun forging, when the casting temperature is high. This arises from the fact that a high casting temperature is favourable to the growth of chill crystals; but it may arise also because non-metallic impurities, not strictly due to segregation, have a better chance of escaping to the centre and top of the ingot when the casting temperature is high. A portion at least of such impurities may be eliminated in the furnace by careful working.

(C.) Mr. Ashdown has permitted reference to a direct experiment made on this subject. He prepared a longitudinal section through a large ingot which was cast partly in an iron mould and partly in a loam mould. The result is shown very clearly in Fig. 25. Mr. Ashdown has allowed us to examine also the results of his many large-scale experiments along similar lines, and we were gratified to find them in agreement with our own observations and deduced conclusions.

(D.) Other makers of large ingots have been known to affirm that cracks on the corners of such ingots (generally due to high casting temperature) may be taken as a sure sign that the ingot is a good one, *i.e.*, good in respect to freedom from ghosts outside the trepanned core. The effects of high casting temperature in the direction indicated may be admitted, but the remedy is a desperate one, and it may well be asked whether it were not better "to bear the ills we have than fly to others that we know not of." If we bear in mind the difficulty of controlling casting temperatures, these remarks will suggest, without further comment, why gun ingots made under apparently identical conditions are diversely satisfactory.

The net effect of a high-cast temperature is harmful, and it is doubtful whether an exception should be made of gun ingots. It increases the amount of total shrinkage; it increases the number of contraction cavities and intercrystalline cracks (see Fig. 26); it adds to the weakness of the ingot along planes which lie between the corners and centre of the ingot, and it heightens the danger of clinking in the reheating furnace.

The assumption that an ingot is a homogeneous piece of metal, apart from piping or segregation, is not supported by observation. Take, for example, the well-worn statement that the extension of a round bar of hot steel by a method which includes the revolution of the bar on its own axis will cause the centre of the bar to become hollow. There certainly is a tendency at all times for the bar to split, and it will no doubt actually do so if the working is sufficiently drastic and prolonged, because the simultaneous revolution and elongation of the bar produces a transverse shearing movement through its centre. But whether it will occur or not in an operation carried out always in the same way depends on the properties of the steel, and experience shows that it occurs invariably with some bars but not with others made from the same ingot.

FIG. 26.—RELATIVE SHRINKAGE AND CONTRACTION IN "HOT" AND "COLD" CAST INGOT.

Use has been made of a method which secures the simultaneous revolving and extension of bars under well-defined conditions as a means of comparing the strength of the central axis of ingots cast under different conditions. The ingots were rolled into bars, and these were cut into lengths for testing purposes. From the usual form of ingot only those bars corresponding to the lower third would stand the test without splitting. When cast into an inverted mould about three-fourths of the ingot would produce bars capable of withstanding the test; but if cast very hot even the inverted ingot would not make satisfactory bars.

Some tests were made on bars prepared as follows:—The ingot was cogged into a slab; this was sawn longitudinally down the centre, and each half was rolled into test-bars. In these tests the axis of the bar would not correspond either with the axis of the ingot or any plane of weakness existing in the ingot, and it is notable that out of three hundred tests not a single piece disclosed a split centre.

It is not so easy to make quantitative tests across the planes of weakness originating at the corners of ingots, and the steelmaker is well pleased if he can avoid any obvious defects arising from them. Their presence, however, should not be neglected by the steelmaker nor ignored by the inspecting engineer. They are unavoidably present in greater or lesser degree, depending on the shape of the mould and the manner in which the steel is poured into it, and more especially on the temperature of the steel. Defects arising from the said planes of weakness are well known; they appear, for example, in the tyre blanks during the becking operation or earlier.

Owing to the higher coefficient of shrinkage of stearine as compared with steel, and its smaller resistance to tensile stresses, it is possible to exaggerate the defects likely to occur in steel ingots. In Fig. 26, for example, a stearine ingot cast in an inverted mould from an unfavourably high temperature is seen to be defective almost to its base. Nothing so visually discomforting as this is likely to occur in a steel ingot, but it is surely an advantage rather than otherwise to have tendencies in the steel we make widened into visible defects in the material used for experimental purposes.

Stearine can be used also to illustrate the general principles of segregation, and to demonstrate some of the causes of spongy and blown ingots. Its value for teaching purposes can hardly be over-estimated.

MR. ROBERT BURT, manager at the Banknock Pits, Dennyloanhead, has been made the recipient of a handsome presentation on the occasion of his leaving to take up another position at Braidwood.

Gas Furnaces and their Utility.*

By Ralph Hackett (Glasgow).

The furnace expert has to be a man of tact and discretion. It necessarily follows from the nature of his business that he will often learn items of an extremely confidential nature, and he must remember not to divulge any of this information, while yet adapting his knowledge to suit the requirements of the case and storing it in his mind as an aid to solve other cases that may arise. A summary of the study necessary to become competent as a fuel expert may be of some use to those who wish to specialise in this branch; and therefore the following list is included:—(1) The heat treatment of steel in all operations (this is most important); (2) the melting of metals, such as copper, gunmetal, yellow brass, aluminium, and all low-temperature metals; (3) forging, including bolt and rivet making and heating; (4) plate heating, drop forging, and welding; (5) large ovens, for such work as enamelling, japanning, and cores; (6) the combustion of gas as applied to furnaces, when using town's pressure, high-pressure gas, and air-blast; (7) the limits of temperature when using one or other of the above; (8) the application of gas as a fuel in furnace construction, and the laws governing same, compared with other fuels; (9) flue draft, and its effect on the furnace.

Heat Treatment of Steel.

There are three systems of furnace-heating by gas, but the method most successfully adopted is that of gas under normal pressure with air blast. Special processes, however, have their own particular requirements. For instance, the heat treatment of carbon steel covers several operations, as follows:—

Carbon Steel.—Annealing requiring a temperature of 880 deg. C.; case-hardening, 925 deg. C.; hardening, 740 deg. C.; tempering, 220 deg. Fah. upwards, and according to the purposes for which the articles are intended. As will be noticed, all the temperatures mentioned are below 1,000 deg. C., and assuming this as the maximum required at any time, the furnace most suitable would be a natural-draft oven. The dimensions would be decided by the amount of work that has to be done. As a guide, however, it may be mentioned that an oven measuring 36 in. by 24 in. by 12 in. high would be generally a convenient size, and capable of taking at least half a ton of work as its maximum load. The maximum gas consumption in a furnace of this description would be about 500 cubic feet per hour, and to maintain the maximum temperature 300 cubic feet per hour.

Natural-draft furnaces are efficient for temperatures up to 1,000 deg. C. (1,832 deg. Fah.). Above this, it is advisable to use air-blast. In the furnace fitted with air-blast the recuperative powers are 25 per cent. better, with a corresponding increase in production and a saving in gas. Added to this are the extra cost for blower, power, and piping, while the natural-draft furnace is independent of either, and can be run night and day without attention. The determining factor, however, in most cases must be that of temperature.

High-Speed Steel.—As this class of steel is one of the most difficult to harden, on account of its high hardening temperature (which is about 1,260 deg. C.), a special type of furnace is necessary to attain and maintain this temperature, and no type of furnace can be relied upon to give the uniform results that a gas-fired one will give. In this case gas with air-blast must be used, and the furnace must be provided with a pre-heating chamber heated by the waste gases from the lower or high-temperature chamber. As these furnaces are made in various forms, the nature of the work will determine the type to be used. The most common types, however, are the twin ovens or muffles for taps, dies, and other similar work, and the crucible type for reamers and twist drills, which must be hardened vertically to prevent any warping.

Metal Melting.—The melting of metals is done most successfully with gas-fired crucible furnaces, the type varying with the nature and quantity of metal, and the purpose for which it is to be used. The most common forms of furnaces used are the "tilting," capable of dealing with quantities of from 120 to 600 lbs., and the "stationary," in twin and single type, which will deal with quantities up to 200 lbs. Each and all of them can work with gas and air-blast at 2 lbs. pressure, or high-pressure gas at 12 to 15 lbs. pressure. Copper, gunmetal, yellow brass, aluminium, and many other metals of a similar nature can be melted in quantities of from 60 to 600 lbs., the consumption being 3.5 cub. ft. per pound of metal melted. Lower gas consumptions have been obtained, but the average given is for practical working. The following are the results obtained from a crucible furnace in melting brass:—

First Heat from Cold.

Time.		Index.	Scrap metal.	Loss.
hr.	min.			
2	2 ..	394,070 cub. ft.	.. 60 lbs. yellow scrap	.. 2½ lbs.
3	20 ..	394,380 ,,		
1	18 ..	310 cub. ft. = 5.16 cub. ft. per lb		

Second Heat.

Time.		Index.	Scrap metal.	Loss.
hr.	min.			
3	30 ..	394,380 cub. ft	.. 60 lbs. yellow brass	.. 2 lbs.
4	25 ..	394,590 ,,		
0	55 ..	110 cub. ft. = 3.5 cub. ft. per lb.		

Third Heat.

Time.		Index.	Metal ingots	Loss.
hr.	min.			
4	35 ..	394,590 cub. ft.	.. 60 lbs. yellow brass	.. 2 lbs.
5	22 ..	394,775 ,,		
0	47 ..	185 cub. ft. = 3.08 cub. ft. per lb.		

The above three melts combined make a total of 180 lbs. of metal melted in 3 hours, for a gas consumption of 705 cub. ft., which works out at 3.9 cub. ft. per lb. of metal melted.

The following results are the average obtained under working conditions when using a 300-lb. tilting furnace fitted with air-blast, the metals melted being copper, gunmetal, and yellow brass:—

Average	working period per day	= 10 hours.
,,	number of melts of 300 lbs. each = 5 melts	= 25 cwts.
,,	time for each melt	= 2 hours.
,,	gas consumption per lb. of metal for casting	= 5 cub. ft.
,,	gas consumption per lb. of metal for ingots	= 3.75 do.
,,	life of pots	= 35 heats.
,,	,, furnace	= 6 months.

* Abstract of a Paper read before the North British Association of Gas Managers.

It is considered that two tilter furnaces will do the work of six 150-lbs. coke-heated pit fires, and the working costs average about the same as the six coke fires; but gas has the usual advantages which are considered important.

Another set of figures has been given by a Glasgow firm—Messrs. Whyte, Thomson & Company—and shows a considerable saving in the working cost experienced by them in using gas for power and manufacturing purposes.

By the old system (using steam power and coke for furnaces melting brass and gunmetal) the following was the cost:—

One year's account for power	£75
,, ,, ,, coke (coke at 16s. per ton)	60
	£135

The average number of melts per day with coke = 4.

By the new system (using a 34-h.p. gas engine and crucible furnace) the results obtained were as follow:—

	£	s.	d
One year's account for power	49	14	6
One year's account for furnace (gas at 1s. 6d. per 1000) manufacturing rate	55	4	0
	£104	18	6

The average number of melts per day with gas = 6.

Hence we see a saving effected of £30 1s 6d., with a 50 per cent. additional output.

Temperature Recording.

The thermo-electric pyrometers are the type most generally employed for recording the high temperatures used in industrial work. The outfit consists of the indicator, the thermocouple, and connecting leads, and can be had either portable or stationary as desired. This is a set to be recommended where only one furnace is used, and where several may be located at different portions of the building.

In munition works there are batteries of furnaces, and, without the use of switches or surplus connections, it is possible to get a correct reading of at least four furnaces on one chart by introducing a thread recorder. Each furnace temperature is shown on the chart in different colours by a series of dots caused by a lever depressing the thread on the chart every minute, the chart being graduated for time and temperature. In this way a permanent record is made and kept for future reference.

Some means of temperature control should be provided with every gas furnace, no matter what type nor for what purpose it is desired, and most particularly where very high temperatures have to be obtained. Standard pyramid cones, which can be had up to 1,860 deg. C., are very useful in cases of high temperatures, and where doubts are likely to be raised. They also serve as a check on any pyrometer set to prove the correctness of same.

Gas and Air Mixing.

The use of gas furnaces has led to the introduction of other appliances, known as gas and air mixers, owing to the difficulty experienced in obtaining a proportionate mixture when gas was used at normal and air under pressure. Most of these "mixers," while improving the working of the furnace, still leave too much dependent upon the operator's skill and ability to adjust the air and gas valves so that they will give complete combustion at all times. Having found this to be detrimental, and being desirous of overcoming the difficulty, the author introduced a mixer, and so far the results have been all that could be desired. With it a small excess of gas will produce an effective reducing atmosphere.

The Use and Abuse of Glue.

By James McLachlan.

While glue is one of the most important things in a pattern-shop, and does not receive the attention it merits, yet it is too much used. The British climate is too humid for an unqualified use of glue in all circumstances. While the cabinetmaker relies almost wholly upon glue, the patternmaker should regard it as a temporary expedient for holding light and delicate work together which is jointed, and where it is impossible to use screws or nails at all, or at least inadvisable until the shape is formed. A glued-up pattern may measure all right in the pattern-shop, and look durable, but when it meets the varying temperature and conditions of the foundry it may fall to pieces. When glue is used the pattern should be painted and given several coats of shellac varnish as a waterproof coating. Unless the patterns are to be painted and varnished glue should not be used at all. For this reason boards for loam work should never be glued.

It should not be left to everyone in a pattern-shop to tinker with the glue stove. The foreman ought to keep a close eye on it, and it is advisable that a handy labourer be deputed to attend to it, or better still, a young lad. To be useful the glue should be in perfect condition. If the youngest boy is made responsible for it, he will get to know the best working consistency.

There are various ways of preparing glue. In some shops the cakes of glue are broken up and placed in the boiling pot without any previous steeping. This is not good practice; the glue ought to be broken up and steeped in a pot, with just enough water to cover it, for about 24 hours before it is boiled. It will form into a thick jelly, which will quickly melt when placed on the stove.

Some shops, however, run to the opposite extreme, and steep a large quantity of glue which cannot be used for weeks. The result is that instead of glue, a sort of syrup is formed, which is unreliable.

The best glue does not hold well on end grain, but if the end grain is first coated and the glue allowed to sink in for a minute or so, and then another coat applied, it will be fairly effective. It is not always possible to rub glued joints, but all superfluous glue should, if possible, be rubbed out. It is a great mistake and a great waste to swim the glue on the job. It always pays a firm to supply first-class brushes. The glue can be applied sparingly, and if the work is thinly coated, two or three rubs, pressing on the surface the while, are sufficient to squeeze out the surplus glue. If the glue is good, it will be impossible to push it more, and a good joint will result.

In glueing leather fillets, if the work is not to be painted or varnished, the fillets should be varnished, to prevent them from dropping off in the mould.

OVER-PICKLING OF CASTINGS.—Cast iron that has to be galvanised usually requires to be pickled first, even though it may have been "tumbled" or sand-blasted to clean it. After pickling, however, sometimes castings will be very difficult to galvanise, taking the zinc badly. This results from over pickling, which allows the acid (either sulphuric, muriatic or hydrofluoric) to attack the iron and expose the graphite excessively on the surface. This defect can be remedied by brushing and scouring until the carbon is removed, but if it is not given this treatment, but is put directly into the electrogalvanising solution, the zinc will not deposit on it well, the carbon being a poor conductor.

Use of Borings in Cupola Operations.

In a Paper on this subject read before the American Foundrymen's Association the author, Mr. James A. Murphy, points out that the melting of iron borings and even steel chips in the cupola for the double purpose of reducing mixture costs and bettering quality is not by any means a new practice. The melting of chips loose in the cupola has been tried both alone and in combination with regular mixtures with very indifferent results. From the results of tests the author concludes there is no better practice than the use of stovepipe lengths filled with chips.

These stovepipe lengths, he continues, should hold about 50 lbs. It is preferable to use either a wood, iron or steel disc for the top or bottom of the stove-pipe containers, which can be filled at the machines by machinists' helpers at very little if any cost, as the borings must be taken away in any event. The cost of preparation for the cupola is about 10s. per ton.

On three different occasions the author melted 10 tons of these canned borings alone, using a blast pressure of from 9 to 10 ounces, the regular blast being from 14 to 16 ounces. All three of these heats showed a loss of less than 2 per cent., which seems remarkable. The charges were carefully weighed. A 10-ton ladle was weighed on a crane scale and then placed under the cupola spout, and when the contents of the cupola were run into it, it was weighed again with the result mentioned. The iron in each case was white and in no way fit for commercial machinery castings. It showed no tendency to stick to the ladle but was hot and fluid. A 6-in. by 6-in. section poured from the ladle was white all through, not a trace of graphitic carbon being visible near the centre.

The melting of borings in stovepipe containers is being practised by a large number of American foundries engaged in both light and heavy work. There is no patent on the process, and it is beyond question a thoroughly successful method.

The briquetting of borings by the German method, that is, subjecting them in suitable moulds to great pressure, is a successful method but the cost is high and there is a considerable melting loss. It is said that the breaking or spalling of the corners and edges of the briquettes represents a great loss. The briquetting of borings through the use of cement or any other wet binder is without question a great failure. The rapid generation of oxygen when moisture comes in contact with the borings soon leaves only a lump of rust to put in the cupola, and when used in this way is productive of bad castings, as pin-holes and so-called blow-holes are prevalent. The melting loss by this method was found by experiment to reach as high as 60 per cent., while the resultant metal was bad. Castings poured with it for experimental purposes were very unsound and literally honeycombed with holes, while on the other hand castings poured from similar metal, taken from a ladle that was filled from the containers, were sound all the way through and showed no signs of pin-holes or any other unsoundness.

With the cans or containers no extra labour is involved on the charging floor and the given amount to be put on any charge can be as evenly distributed throughout the charge as any component part of it. This filling labour should hardly be counted under most circumstances as the borings must be taken away from the machines and the helper may as well fill the cans as use any other receptacles. Borings melted by this method are a decided strengthener of castings and tend to give a closer gain. The author has used them in various percentages in all kinds of work, from the heaviest parts of high-class machinery down to light automobile castings, with unvarying beneficent results.

The Melting of New Scrap Iron and Steel Briquettes

The question of the employment of iron and steel briquettes is discussed in a recent issue of "Stahl und Eisen," by Herr R. Fichtner, of Duisburg-Wanheim, who first points out that very considerable quantities of material are yielded annually in the form of turnings, croppings, etc. Thus in 1912 the total consumption of old and new scrap was as follows :—

German Consumption of Old and New Scrap in 1912.

	Tons.
From Puddled-iron works	18,359
„ Basic iron and steel works	5,228,950
„ Iron and other metal foundries ..	860,699
Total	6,108,008

It appears that no statistics are available in regard to the tonnage yield in the matter of turnings, etc., from iron and steel turning, planing and milling operations. Scrap iron and turnings in conjunction with pig-iron form the starting point in foundries and steel works for the production of new rolled products, castings and forgings, and in the course of this movement of the material one ton of heavy scrap or steel turnings represents in itself one ton of iron and steel. Now, whilst this unit of wrought-iron and steel scrap is sold in the market at from 45s. to 55s. per ton, a ton of steel turnings only has a value of from 30s. to 37s. A similar state of affairs prevails in regard to cast-iron borings, as cast-iron scrap commands 54s. to 65s., whereas cast-iron borings only yield from 32s. to 46s., according to local conditions. As a reason for the lower value of turnings as compared with scrap the author recalls that the former are composed of loose materials, whilst the latter is dense and solid iron. For instance, 1 cubic metre of iron cast into an ingot weighs from 7.25 tons to 7.8 tons. On the other hand, 1 cubic metre of cast-iron turnings measured in a box only weighs about 2 tons, 1 cubic metre of hard steel turnings (shell turnings) weighs 1.43 ton, and 1 cubic metre of loose mild-steel turnings only 0.160 ton to 0.520 ton. The converse is the case with the volume, as the smaller the weight of the unit the greater is the volume. It is shown, for example, in one case that the volume of loose iron and steel turnings amounts to 48½ times the volume of a massive ingot of the same weight. But the superficial area of the turnings increases to a much greater extent than the measure of space, as the turnings occur in very thin and narrow layers.

Both scrap and turnings are returned for remelting in the foundries and ironworks. The big volume of the turnings naturally necessitates the possession by the purchasers (the steel works) of large storage accommodation, and involves them in greater costs for transport and delivery, as the carrying capacity of the trucks cannot be fully utilised with loose turnings. In addition, loss is incurred through the rusting of the turnings stored in the open air, in consequence of the big surface exposed

to moisture and the atmosphere. The loose turnings in the melting process also offer a much greater surface to the flames or hot gases than solid and lumpy scrap, and as a consequence the loss in the reduction is far greater in the former case than in the latter. Moreover, the chemical composition of the turnings is widely different, and may cause difficulties in this direction when being remelted in open-hearth furnaces, whilst at the same time they cling closely together and can only be separated with difficulty, thus requiring a longer time and involving increased wages for charging.

It is possible to reduce steel turnings on the site where they are produced. But the conditions are otherwise in regard to cast-iron turnings. Like steel turnings, the cast-iron variety can also be remelted in open-hearth furnaces, which operation is extensively carried out. The price paid by the steelworks for cast-iron turnings is, for similar reasons to those for steel turnings, very low as compared with scrap iron. Most cast-iron turnings come from machinery works, many of which possess their own foundries, and it would therefore seem appropriate to remelt these turnings there. With few exceptions the foundries in Germany only work with cupola furnaces. But if the cast-iron turnings are charged into the cupolas they cannot be reduced economically. In fact, the remelting of them in a loose condition in cupolas has never led to practical results, and their re-use in foundries is therefore excluded.

The author proceeds to state that a decided change in regard to the utilisation of turnings took place in 1909, the incentive to briquette them having probably been suggested by the successful work in the briquetting of ore and coal. A briquette formed of cast-iron turnings and compressed under high pressure offers, in so far as it holds together and does not fall to pieces, a much smaller surface to the hot current of gas than the same charged into the furnace in a loose condition, the briquette approaching in its solid texture solid scrap. Well-pressed briquettes of cast-iron turnings (of a weight of from 10 to 12 kg.) have a specific gravity up to 5.8, whereas cast-iron has one of 7.2. If this density is represented by 100 the cast-iron briquettes show an 80-fold compression. The specific gravity of steel-turnings briquettes is 5 to 5.2, and that of wrought iron or steel 7.8, the compression in the case of the steel briquette consequently being 66-fold.

Experiments undertaken with well-pressed briquettes of cast-iron turnings showed that they can be advantageously remelted in cupolas. If briquettes only were remelted the waste considerably increased on a simultaneous slagging of the furnace; but no great waste occurred when the operation was conducted with pig-iron and scrap with up to 30 per cent. of briquettes. As a consequence the possibility of reducing briquettes of cast-iron turnings was demonstrated, and it was also found that the iron resulting from the reduction presented a fine texture. Experiments made in 1910 in the foundry of the Maschinen-Fabrik Augsburg-Nüremberg indicated how the strength increased with the increasing use of briquettes in the charge. In a mixture of hematite and briquettes of cast-iron turnings the briquette content was raised from 20 to 90 per cent.; and a constant increase took place in the tensile and transverse strength. But with the larger addition of briquettes (80 to 90 per cent.) the iron began to be brittle and its strength to decline. One disadvantage always observed was a higher absorption of sulphur in the iron, according to the increase in the percentage of briquettes.

During 1915 Prof. Wüst carried out experiments in the foundry of Sulzer Brothers at Winterthur. Charges were employed consisting of hematite and Luxemburg iron, together with an admixture of briquettes formed of cast-iron turnings in proportions rising from 5 up to 25 per cent., so that the composition of the charge in carbon, silicon, manganese, phosphorus and sulphur remained approximately the same. The experiments resulted in an increase in the transverse strength with test bars up to 35 per cent. and in the tensile strength up to 50 per cent. It has been established that:—(1) The total waste increases proportionately to the addition of briquettes; (2) that the carbon loss does not materially increase; (3) that the proportionate loss in silicon increases with an increasing use of briquettes; and (4) that an increased absorption of sulphur through the briquettes does not occur.

Match Plates and Aluminium Patterns.

This subject was mentioned in a Paper read before the American Foundrymen's Association by Mr. A. E. Howell, who remarked on the substitution of aluminium for iron patterns and the hinged match-plate for the loose pattern for light castings. The development of the manufacture of aluminium permitted new uses for it, and the foundry appropriated this material rapidly for patterns, as it got cheap enough to be available—but not as loose patterns. The match-plate was concomitant with the aluminium pattern. This gave the necessary rigidity and strength, and assured straight edges. With a match-plate the skilled work is mainly performed in the pattern shop; but still the moulder must still see to it that his sand is in proper condition; he must know just how to ram and how to pour and, above all, he must know exactly how to place his bottom board and clamp it to prevent the sagging of the drag.

One might say that in moulding from a well designed match-plate the skill required is almost eliminated, but for the fact that two things may happen and do happen. Either the drag settles or drops away from the plate, making excessive weight in the casting, or the mould is "clamped-off" by getting too much sand under the bottom board. This requires judgment and care, especially with castings of large, unbroken surface.

The advantages of the aluminium match-plate are several. Breakage is almost eliminated. The wooden follow-board is done away with, only a skeleton support for the larger plates being necessary; the filing and dressing of the aluminium plates is much more rapid and the total cost is about the same as the total cost of the iron patterns. There is the necessity of having flasks fit the plate, but this is overcome by making all flasks and plates to certain standards.

It may naturally be asked how patterns that are matched are fitted, as exact fitting cannot be done in the wood. We take off non-shrinking metal castings from the wood. These are dressed and fitted and the plates made from them. The non-shrinking metal is a mixture of lead with enough tin to stiffen it and secure necessary straight lines and enough antimony to counteract the shrinkage. We use a ¼-in. square by 12-in. bar to test when this is the case. We also cast a bar from each lot of aluminium to ascertain its shrinkage and make allowances accordingly. This we find usually varies from 0.170 to 0.180 for No. 12 metal.

Manufacture of Alloy Steels

(*Continued from page 543*).

Heat Treatment of High-speed Tools.

The heat treatment given to high-speed steels for the commoner uses as lathe and planer tools has generally been simplified by heating to incipient fusion and quenching in oil. Cooling by an air blast and double treatment, which were formerly recommended, are now not common, except that a second (drawing) heating is given to milling cutters and similar tools, the temperature imparted to the tool depending on the material to be cut.

The treatment is usually done by the blacksmith, who heats the tool in his forge fire and then immerses it in a tank containing enough oil so that its temperature does not rise materially. Ten gallons of oil is a common quantity to use when the size and number of the tools is moderate, as in most shops. The fire is a deep compact coal fire, the coal in the centre where the tool is heated being pretty thoroughly coked, that is, most of its volatile matter distilled out. This manner of heating has the advantage that free oxygen does not get at the tool to oxidise it, but its environment is non-oxidising or even reducing, owing to the presence of an excess of burning carbon surrounding the tool. Any flame is more or less oxidising, at least unless heavily charged with smoke or free carbon, and a piece of steel heated directly by a flame as in the ordinary heating chamber of a furnace is likely to be somewhat oxidised on its surface, the depth to which the oxygen penetrates varying according to the conditions, particularly the temperature, the access of air, and the length of time. Heating in a muffle will also result in oxidising the steel unless extraordinary precautions are taken to keep out oxygen or to consume all that enters. The temperature of quenching, usually about 1,260 deg. C. (2,300 deg. F.), is determined by the fusion of the scale and its visible collection into drops or beads on the surface of the tool.

Quenching is done by quickly plunging the heated tool into the oil as soon as it has reached the desired temperature and moving it about in the oil until cold. Cooling in oil is thought by some to give a better tool than cooling in the air blast, one reason seemingly being the protection of the steel from free oxygen while it is hot enough to be oxidised thereby. The oxygen of the air blast forms a scale of oxide on the hot steel and the oxygen probably penetrates the metal below the scale to some extent, injuring the quality as deep as it goes. A tool on its second grinding when the oxidised metal is removed may then give better service than on the first, unless the first grinding has for that reason been heavy enough to remove the oxidised metal.

In many shops, however, the original treatment recommended by Taylor and White is given, the cutting edge of the tool being heated to incipient fusion and then immersed in a bath of melted lead at about 565 deg. C. (1,050 deg. F.). The heating is done in a small furnace over a deep coke fire, blown by an air blast, so that the environment of the tool while being heated is substantially non-oxidising. Flames of carbonic oxide play out of the openings through which the tools are inserted, indicating little if any free oxygen within. In these shops, however, milling cutters and other tools that are machined to a particular form are treated by heating them to a slightly lower temperature, in order not to damage the cutting edges, and then plunging them into cold oil. When cooled to the temperature of the lead they are taken out and placed in an air blast to complete the cooling. Some tools desired to be especially tough so as not to break in service are given a second heating to 565 deg. C. and then cooled in the open air or air blast if saving time is important.

Rapid steel when well annealed will bend considerably without breaking, even in as large a section as 2½ by 1¼ inches, the bending being edgewise, as in a tool at work. Gledhill found that one of these steels after having been annealed 12 to 18 hours at 760 deg. C. (1,400 deg. F.) had a tensility of 129,200 lbs. per sq. in., an elastic limit of 89,600 lbs. per sq. in., an elongation of 18 per cent. in 2 inches, and a contraction of area of 35 per cent. The ductility is rather high and would enable a tool to be bent considerably without breaking. Such annealed steel may be rather easily machined for making milling cutters and other shapers that require machining.

Carpenter found that the higher the temperature from which rapid steel is cooled the more it resisted etching for metallographic work. He also found that no tempering change occurred when it was reheated at a temperature of less than 550 deg. C. (1,022 deg. F.) to a visible red in the dark, indicating a stability that is doubtless the cause of its property of red hardness.

Whether a rapid steel is made harder by the heat treatment given it depends somewhat on the condition of the bar before treatment. If it has previously been annealed, the treatment hardens it, whereas heat treatment may not harden a piece in the natural state. Taylor found that some tools having useful red hardness could be filed rather readily. Edwards on the other hand found treated high-speed steels to be exceedingly hard—as hard as any steel could be made by quenching. Gledhill found that high-speed steel was good for turning chilled rolls which are extremely hard and require to cut them the hardest kind of tool.

Trials on window glass of a number of different rapid steels showed that the cutting edge of some but not of all would scratch it. The same was true of the untreated ends of the same tools, as some would and some would not scratch the window pane. The hardness of the steel when cold is not the determining factor of usefulness in any case. It is the hardness when heated under conditions of work. The cutting edge of a rapid-steel tool at work is probably never as hot as the metal just back of it, where the heating caused by the friction of the chip, as it is deflected and rubs hard on the tool, is most intense. The edge itself is kept relatively cool by the cold metal flowing upon it.

Theory of High-Speed Steel.

Carpenter found the heating and cooling curves of a rapid steel to be radically different from each other, and also that the cooling curve when the steel was cooled from 930 deg. C. (1,706 deg. F.) was greatly different from that when the steel was cooled from 1,250 deg. C. (2,282 deg. F.). When

the steel was cooled from 930 deg. C. the curve had an abrupt jog, which showed a great retardation in rate of cooling occurring between 700 deg. C. and 750 deg. C. (1,292 deg. F. to 1,328 deg. F.). The jog did not occur when the steel was cooled from 1,250 deg. C., 320 deg. higher, the line representing variations in rate of cooling being nearly straight. The rate of cooling to get these curves was slow or at least not accelerated, and one cannot say what the curves would be like if the rate of cooling were hastened, as in quenching, but the curves obtained seem to throw much light on the question. The property of red hardness seems to be connected with the elimination of the great retardation mentioned.

The following explanation, based on the work of Carpenter and Edwards, of the properties of high-speed steels, seems to be helpful or even satisfactory:—Their researches on the heating and cooling of these steels have shown that such steels have an extraordinary stability of composition after they have been heated to 1,200 deg. C. (2,192 deg. F.) or more, and that a second heating of 550 deg. C. (1,022 deg. F.) has no softening or drawing effect. It seems fairly evident that red-hardness depends on or is the natural result of these facts. At a temperature higher than 1,200 deg. C. (2,192 deg. F.) a double carbide of chromium and tungsten is formed, which persists largely even when the steel is cooled slowly as in the open air, and more so when cooling is accelerated. This double carbide imparts to the steel a high degree of hardness and is stable at all temperatures up to 550 deg. C. (1,022 deg. F.) or somewhat higher. At 550 deg. C. the steel has a low red colour visible in the dark.

If the above theory be true then at a temperature of 1,200 deg. C. (2,192 deg. F.) the chromium and tungsten must have a stronger affinity for carbon than iron has, whereas at lower temperatures, say from around 930 deg. C. down to the critical point, the affinity of carbon for iron is slightly stronger than that of either chromium or tungsten or both, and the carbon then exists wholly or in part as carbide of iron, or a complex carbide of iron with one or both of the other elements.

Carbide of iron, or hardening carbon which causes the hard condition of iron in simple steel that has been quenched from a temperature higher than the critical point, is unstable at even slight elevations of temperature above atmospheric temperature, its unstableness increasing with the degree of heat, though not being proportional thereto. Boynton has shown that between 400 deg. C. (752 deg. F.) and 500 deg. C. (952 deg. F.) the amount of change and consequent softening is much greater than at other temperatures, either lower or higher. The proportion of carbon in rapid steel should perhaps be only as much as will combine with the chromium and tungsten at 1,200 deg. C. (2,192 deg. F.) and leave none to exist as unstable hardening carbon of hardened simple steel.

Testing and Using High-speed Steel.

A reliable and inexpensive method of quickly testing high-speed steels to show their value is much needed. Herbert and Edwards have used and recommended machines and methods that lessen the time and trouble of testing, but no test seems to take the place of a trial at actual work, because the performance of a tool in one line of work with certain conditions may not be foretold positively by its performance in another with different conditions. Among the reasons are that (1) sometimes greater durability is obtained by changing, that is, increasing or lessening, the speed of the cut, thus changing also the temperature of the tool or (2) a given tool when used at its best speed may be excellent for cutting a certain material, yet prove inferior to another tool for cutting a different material. Thus if selected as the best by trial for cutting a 0.20 per cent. carbon steel it may be surpassed by others in cutting a 0.70 per cent. carbon steel. Physical tests of rapid steels at different temperatures up to 800 deg. C. (1,472 deg. F.) are needed to show the effect of heat on the physical properties of those steels. New uses would probably be suggested by the results of such a series of tests.

A rapid-steel tool does not finish the piece being cut as nicely as does a simple steel tool, as the rapid steel does not keep a fine edge with a light cut and slow speed of, say 20 per minute. The durability of such a tool taking a light cut is much greater at a higher cutting speed, at which the tool is hotter, showing that the strength or the toughness of the steel or both are augmented by the higher temperature. Unhardened simple steels with 0.6 to 0.7 per cent. carbon get stronger but less ductile with a rise of temperature up to about 300 deg. C. (572 deg. F.). If, as the temperature rises, high-speed steels get stronger without loss of ductility but perhaps with an increase, within limits of course, a physical reason for their great durability is provided.

In 1910 Herbert announced the discovery that any rapid-steel tool and some simple steel tools may have two rather widely separated cutting speeds at which the tool is more durable than at speeds above, below, or between. Thus out of many cases described, one tool cooled in an air jet had nearly equal maximum durability at two speeds—50 and 90 feet per minute, whereas at 65 feet the durability was less than one-half of that at either of the other speeds. This discovery no doubt accounts for some of the anomalies encountered in tool steels as well as other steels the properties or performances of which are not what would be expected from their composition and other attributes. Thus a tool may be condemned when an increase of its cutting speed would cause it to give satisfactory service and durability. Rapid steel will do its best cutting when hot. A desirable practice followed in some shops, is to heat a tool to near redness before putting it to work.

Machine Tool Design.

When Taylor and White first introduced rapid steels it was thought that the higher cutting speeds afforded constituted the sole benefit to be derived from them, and as the higher speeds, although consuming more power about in proportion to the increase in speed, did not increase materially the stresses on the machine tools, it was thought that the latter merely needed to be speeded up in order to get the full benefit from the new steels. But is was soon found that the rapid steels in addition to cutting at higher speeds were capable of taking much heavier cuts, which proportionately increased the stresses on the tools. To take full advantage of the heavier as well as the more rapid cuts machine tools were generally re-designed to provide the great strength required, and were supplied with proportionately more power. The resulting economies all over the world have been enormous.

The advantages from the use of rapid steels as compared with the use of simple tool steels are in

the lessened costs of the ordinary operations of finishing iron and steel because of:—(1) More rapid cutting speed. (2) Heavier chips cut, hence larger cuts and feeds. (3) Saving of power per unit of metal cut off. (4) Lower cost of plant for a given output. (5) Lower general and overhead charges connected with manufacturing iron and steel products.

Since the original Taylor and White patents for treatment of high-speed steels were issued in 1901, others have been granted for almost every possible combination of elements which were in any way thought to be useful or valuable constituents of tool steel. Chromium and tungsten were generally included, though not always. Nevertheless, most makers now aim at substantially the same foundation composition, with varying amounts of vanadium and sometimes with cobalt.

gained an extensive market. In 1913 about 90,000 tons of ingots is thought to have been made, of which about 75,000 tons was sold in rolled and forged products. These steels are almost all made in the open-hearth furnace, the chromium and vanadium alloys being added shortly before casting. The hot working of chrome-vanadium steels presents no especial difficulties. The total amount of alloying elements is not large in the commercial grades, and the steel acts in the press and rolls much like simple steels with somewhat higher carbon contents.

Chrome-vanadium steels are in their physical properties much like chrome-nickel steels, but they have a greater contraction of area for a given elastic limit than the latter. This higher contraction of area in the pulling test seems in some way to be associated with machinability, as chrome-

Composition and Properties of Chrome-vanadium Steels in Natural Size.

Sample No.	Composition.							Tensile properties.				
	C.	Mn.	Si.	S.	P.	V.	Cr.	Tensile strength.	Elastic limit.	Contraction of area.	Elongation in 2 in.	Ball hardness
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Lbs.	Lbs.	Per cent.	Per cent.	
1	0.57	0.84	0.27	0.03	0.01	0.31	1.36	98,000	75,750	68.5	28.1	175
2	0.46	0.48	0.20	0.02	0.01	0.14	1.17	82,250	52,500	71.0	34.0	160
3	0.18	0.32	0.18	0.02	0.01	0.20	0.74	60,500	42,900	75.0	43.0	133
4	0.30	0.65	0.10	0.04	0.04	0.18	0.90	—	45,000	69.0	35.0	*155

* Annealed.

Composition and Properties of Chrome-vanadium Steels in Heat-treated State.

Sample No.	Composition.							Tensile properties.					Treatment.*
	C.	Mn.	Si.	S.	P.	Cr.	V.	Tensile strength	Elastic limit.	Contraction of area.	Elongation in 2 in.	Ball hardness.	
	Per cent.	Percent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Lbs.	Lbs.	Per cent.	Per cent.		
1 ..	0.30	0.65	0.10	0.04	0.04	0.90	0.18	—	101, 00	64	20	255	899° W; 704° A.
2 ..	0.30	0.65	0.10	0.04	0.04	0.90	0.18	—	180,400	43	10	430	899° W; 454° A.
3 ..	0.30	0.65	0.10	0.04	0.04	0.90	0.18	—	200,000	52	10	429	899° W; 315° A.
4 ..	0.28	0.45	0.26	0.02	0.01	1.00	0.18	96,500	79.000	75	34	187	899° O; 676° A.
5 ..	0.40	0.75	0.26	0.01	0.01	1.00	0 17	148,000	120 000	53	20	270	926° O; 676° A.
6 ..	0.40	0.75	0.26	0.01	0.01	1.00	0.17	221,000	200,000	48	11	435	926° O; 426° A.
7 ..	0.57	0.37	0.20	0.02	0.01	0.69	0.22	188,200	177,500	57	14	330	——; 426° A.
8 ..	1.06	0.36	0.22	0.02	0.02	0.95	0.11	135,550	126,750	49	21	248	——; 648° A.
9 ..	0.41	0.49	0.12	0.03	0.03	1.09	0.11	86,900	77,250	70	33	152	——; 754° A.
10 ..	0.25	0.50	0.10	0.03	0.02	0.95	0.75	131,700	113,000	56	18	—	—

* The first temperature given for each sample is that at which the steel was quenched, and the second the drawing temperature: W, O, and A represent water, oil, and air, the three cooling media used. Samples 8, 9, and 10 were hardened before being drawn at the temperatures given.

Miscellaneous Uses of High-speed Steels.

An important use for high-speed steel is in the exhaust valves for automobile engines, where it has given excellent results. These valves operate sometimes at a red heat and seemingly the property of red-hardness that the steel possesses enables it to give good service in these valves.

High-speed steel is being used also in the manufacture of extruded brass to form the die through which the extruded metal is forced. The temperature of the brass is high, near its fusion point, and seemingly the red-hardness of the steel enables the steel to perform this service satisfactorily.

A good file or a good cold chisel may be made of rapid steel, but they are not good enough to justify their cost as compared with those made of simple steels.

Chromium-Vanadium Steels.

Chromium-vanadium steels, usually called in the trade chrome-vanadium steels, are the latest development in structural alloy steels that have

vanadium steel with an elastic limit of 150,000 lbs. per sq. in. may be machined rapidly, whereas a chrome-nickel steel having such an elastic limit would quickly dull the cutting tool if cut at the same speed.

The greater part of the chrome-vanadium steels made goes into automobiles. They are preferred by some because of their greater freedom from surface imperfections, notably seams, which steels containing nickel are prone to have if the ingots are at all unsound. Vanadium is a deoxidiser, whereas nickel is not, so that vanadium, when present, favours quality, and the smaller proportion required enables it to compete with nickel, even though its cost is five or six times as great.

Chrome-vanadium steels are nearly always used in the heat-treated condition, but there are exceptions even in automobiles, as some frames, forgings, and shafts are made of the steel in its natural state. When heat-treated these steels are both hardened and drawn at slightly higher temperatures than are used with nickel-chromium

steels to get similar properties. These temperatures are given in the table of heat-treated chrome-vanadium steels.

Some chrome-vanadium steel is said to be used in armour plate of medium thickness (4 in.), which is not face-hardened but has high properties imparted by heat treatment. Some such steel is used in high-duty forgings and structural parts of machines.

Recovering Alloyed Elements.

As the alloying elements of alloy steels are all more valuable than iron, some of them very much so, makers of alloy steels wish, of course, to save such elements in their alloy-steel scrap, if practicable without too great cost. The makers can save tungsten, copper, nickel, and cobalt, each of which has an affinity for oxygen and a heat of combustion with oxygen less than the similar properties of iron; however, the makers cannot at present save the manganese, silicon, vanadium, titanium, calcium, magnesium, and chromium, each of which has an affinity for oxygen and a heat of combustion greater than the similar properties of iron. Plans have been proposed for saving some of them. Saving a part of these oxidisable elements in reworking the scrap is in some instances of no benefit, because in replacing the wasted part by the addition of a fresh quantity of the ferro-alloy saturated with carbon there will be too much carbon in the finished steel. This is particularly true of manganese in manganese-steel scrap. The carbon in the alloy-steel scrap is protected from oxidation by the alloying element while the latter is being oxidised. With low-carbon alloy available the case is different, as the content of carbon in the steel may then be controlled.

British Foundrymen's Association.

Scottish Branch.

The first meeting of the 1916-1917 session of the Scottish Branch of the British Foundrymen's Association was held at Glasgow on October 14. Mr. Matthew Riddell occupied the chair. Mr. Riddell, in the course of his remarks referred to the syllabus of lectures for the session, which is as follows :—

October 14.—"Some Things a Foundryman Should Know," by Professor Campion.

November 18.—"Cast Iron," by Mr. E. Adamson.

December 9.—"Aluminium Alloys," by Dr. C. H. Desch.

January 13, 1917.—"Cores: Materials and Comparative Costs," by Mr. A. Naylor.

February 10.—"The Foundry and the Drawing Office; Advantages of Co-operation," by Mr. Elliot.

March 3.—"Electric Cranes," by Mr. Weddell.

March 24.—"Cupola Notes," by Mr. R. B. Robinson; and the annual business meeting.

The President drew attention to the issue of the Branch programme in book-form. It contained an appeal to the members which he hoped would have their serious consideration. In the course of this it was remarked :—

"The present great crisis appears to have awakened many people to the fact that our industries were in danger from the enemy, owing to the greater devotion which he is alleged to pay to scientific and technical details and to our apparent indifference to such matters. It is being strongly urged, therefore, that, if this country is to maintain its supremacy in the industrial war, it will be necessary to devote much more time and closer attention to the development of the science and technics of every branch than has hitherto been the case. This aspect of the question is what has been the aim and object of the British Foundrymen's Association, and its members are thereby performing services of national interest and importance."

Professor Campion then delivered an address on "Some Things a Foundryman Should Know." At the outset he explained that he intended to limit his remarks to the consideration of a few elementary points with regard to the general properties of matter and the atomic theory. His idea in bringing forward these subjects was two-fold: first, because the scientific study of foundry work was of comparatively recent date and many lecturers on foundry-work during the course of their address gave illustrations embodying symbols representing certain chemical elements, which those who had not an opportunity of studying chemistry were at a loss to understand. His second reason was to try and instil in their younger members a desire for further knowledge on the subject.

The lecturer proceeded to explain the nature and properties of atoms, and their combination to form different elements. The smallest particle of a compound contained two or more atoms, and this smallest particle was called a molecule. The term molecule was generally employed to designate the smallest particle of any body which could exist in the free or uncombined condition. The atom of each element was characterised by its weight and power of combining with other atoms. The atom of hydrogen had been selected as a standard with which to compare the weights of the atoms of other elements; its weight was therefore taken as unity, and the weights of other atoms expressed in terms of it.

The lecturer gave a number of black-board demonstrations, illustrating various points introduced in his address. At the conclusion a hearty vote of thanks to the lecturer terminated the meeting.

London Branch.

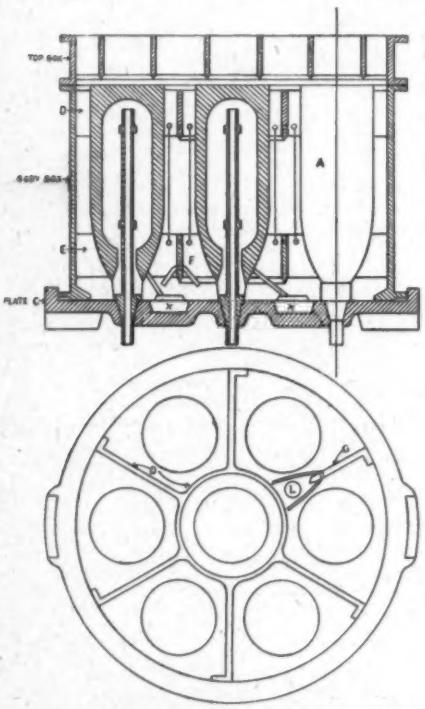
The annual meeting of the London Branch of the Association was held on Saturday, October 7, Mr. A. Willis (retiring Branch President) in the chair. The business of the meeting consisted in the election of officers for the 1916-1917 session, as follows :—President: Mr. A. R. Bartlett (Erith). Vice-Presidents: Mr. T. W. Aitken (Luton) and Lieut. D. Gordon (London). Representatives on General Council: Messrs. W. H. Aston and D. Gordon. The voting for the Branch Council resulted in the election of Messrs. A. Barber, E. M. Boote, C. F. Walker, J. Gaunt, and E. W. Marriott, the Council thus consiting in addition to these gentlemen, of Messrs. J. Oswald, J. Ellis and A. Willis (Past-Presidents); Messrs. T. W. Aitken and Lieut. D. Gordon (Vice-Presidents); Messrs. W. H. Aston, H. O. Beere, F. C. Barker, W. Ellis, B. F. Sperring, and R. Woods. The Secretary, Lieut. Alexander Hayes, 116, Rusthall Avenue, Bedford Park, W., and 165, Strand, W.C., was re-elected.

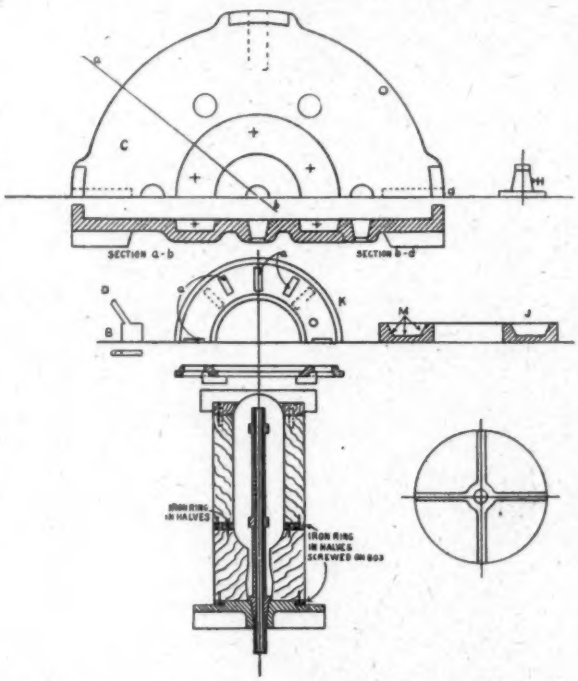
At the conclusion of the buisness meeting the members had tea together, and spent the evening in social intercourse, music and other entertainments.

Moulding Shells.

By C. Thomas.

The top box is an ordinary box 6 ins. deep with bars across and chocks between. It has a flange round the top and four lugs on the bottom. The bottom joint is machined to form a socket-and-spigot joint with the body box, or else two of the lugs are drilled to take dowell pins, which are fastened in the body box. It can be cast open sand. The body box is made without bars, and with flanges top and bottom faced to length, with the bottom flange turned on edge to fit the lugs on the plate. It also has a lip cast round the inside at the bottom to carry the sand, and has holes cast in the body through which to bolt the bars. It can be made the same as a flange pipe. Vent holes are cast in each box. The bars D consist of a ring in the centre with five arms cast





on, of a suitable diameter to fit inside the body box. This ring is made 4 ins. deep, and the arms have a flange on the end with a hole cast in, through which it is bolted to the body-box. It also has holes cast in near the bottom of the arms and ring. The part E is similar to D except that the holes are cast in the arms and ring near the top and bottom as well. The holes in the bottom of D and top of E are provided for the insertion of stout wire which is laced from one to the other after they are fixed in position in the body-box. The holes in the bottom of E are for the insertion of pieces of wrought iron as at F, which will carry the weight of sand. The wire is to stiffen the sand between the patterns. The bar G is made separate from D and E to allow for the down runner to be placed in the mould. It is made the full length of the box, and has some pieces of wrought iron ⅜-in. square section cast in, which are then bent to fit between the pattern and runner as shown. It is bolted to the body box the same as D and E, which latter with G are cast open sand.

The bottom plate C has four feet on the underside to stand on. The seven holes shown bossed up underneath are formed by means of a chiller H, which is turned the same size as the seat on the core bars, and has a large print added to it. The print is to ensure the chiller standing perfectly true when casting the plate. The chillers do away with the necessity of machining the holes. The lugs on the plate are bored out to receive the bottom flange of the box. The channel marked X is also cast in. J is a metal core box to make a core to fill channel X, and come level with the face of plate C. K is ½-in. thick, and of section shown; it has four feet underneath, so that when it is placed in channel of C it stands level, with the exception of the circular print which should be ⅜ in. above the face of the plate. Tht print part should be machined so that it will mould. It has also seven holes cast in to take the runner B, and a round hole drilled through it into plate C. The down runner marked L has a dowel on the bottom to go through the round hole in K, and of such a length to enter into the hole in plate C. This will decide the position of plate K always.

The core bars are of cast iron, and have their seats turned to the holes in the bottom plate C; also collars are cast on as shown to help to hold

the wrapping of straw or other material that the core is rammed round. They should have a clear hole cast through the centre, and a plentiful supply of vent holes drilled in them.

The patterns are of metal ½-in. thick, with a seat the same size as the core bars, and are machined all over. The top end of them can be closed with an iron plug containing the riser and lifter holes. The core box can be made of either iron or wood. If of wood it should have iron rings screwed on to make the joints with. It should be made in two lengths on account of ramming the small end of the core, and in halves to facilitate removal after the core is rammed up. The dome of the core is strickled on. The box is rammed on a plate bored out to take the seat of the core bars.

To mould and cast shells the ring K is placed in plate C, and all the runners B placed in the holes made to receive them. The down runner L is also placed in the plate. The patterns are now placed in the plate and sand bedded round the runners; the body box is placed in position and rammed up in the usual way. The top box can either be rammed on the top of the mould or on a separate plate containing the risers and down runner placed in proper position to correspond with the patterns in the body box.

The patterns and down runners are then drawn out, and the body box lifted up, which will also bring with it the runners B, plate K stopping down in plate C. The runners B can then be removed, also plate K, and the core placed in the channel in plate C, which will give a space for the metal from the down runner to feed all the seven runners when the body box is again placed in position. To ensure the body box finding the same place again the bottom flange of it should have a hole drilled through to fit a dowel cast on plate C. The shell cores are now put into their seats, and can be fastened by means of a pin passing through the core bar and bearing against the bottom plate. The patterns can be fastened by the same method to prevent them moving while being rammed. There only remains the top box to put in place now. This is centred by means of the dowel in the body-box flange passing through the hole in the lug of the top box, or else by means of a socket joint. The bushes round the risers should be of good size to ensure the castings being solid. The runners B are made of wood.

Flexible Chiller.

By Edward Longden.

There is no more troublesome or more annoying defect to overcome than the one illustrated in Fig. 1—a defect which is common to many classes of castings and to most ironfounders. The difficulty, in almost every case, is disproportionate thicknesses or unsuitable metal. Often the moulder is held responsible for such defects, which, at first glance, appear like dirty places. On careful examination the flaws prove to be porosity due to irregular thicknesses or unsuitable metal.

Defects occur at junctions or attachments, and in irregular sections. The metal in such places remains fluid or plastic longer than the thinner parts of the casting, acting as a feeder to the earlier solidified portions. The feeding rod is the saviour of many castings of greatly varied sections, that is, when the rod can be got to reach the heavy parts directly. But in other classes of castings it is unable to reach the sections requiring assistance.

Any attempt to aid, or to arrive at a better uniformity of shrinkage will bring wasters to a diminishing quantity. The writer experimented on troublesome castings with a device similar to the one illustrated in Fig. 2. Its utility was proved.

The device sketched in Figs. 2 and 3 consists of a number of nails held by a thin sheet of wrought iron, and is really a variation of the chilling plate, but has the advantage of being flexible with projecting fingers (nails) which conduct away the heat and distribute it to a considerable body of moulding material and thus dissipate it quickly. Acting in this manner the area in which the nails project coincides more uniformly with the thinner sections of the casting in cooling from the fluid to the solid.

The device is adaptable and can be wired or nailed to that part of the section which will not be faced. Fig. 1 shows the device wired to a core, with

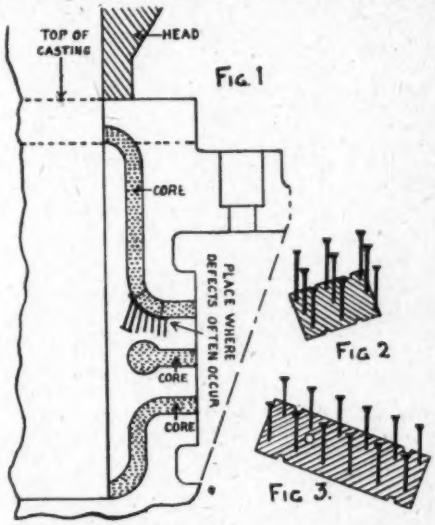


Fig. 1

Fig. 2

Fig. 3.

the nails projecting into the part usually faulty. It is not suggested that the nails be projected right through the section of metal as Fig. 1 demonstrates. The nails can be cut to conform to the shape required and to penetrate to within a reasonable distance from the parts which require facing, etc.

Being of a thin section the nails will unite readily with the metal, if the device is perfectly clean and tinned to prevent oxidation. The remaining portion of the metal (the metal out of immediate contact with the nails) in the section under treatment is a safeguard, and certainly more likely to be sound than if the metal adjoining had not been treated with the "flexible chiller."

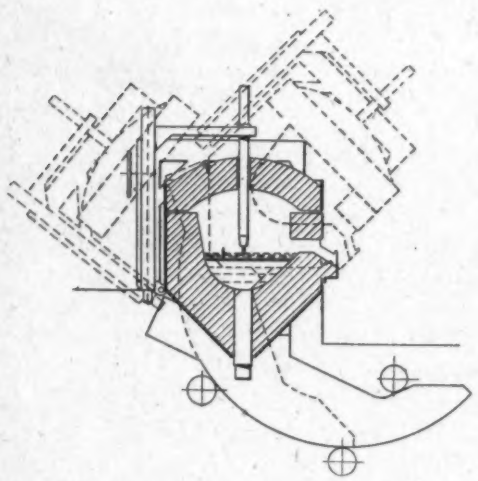
It would be more economical, and perhaps as useful, to manufacture in lengths or sheets so that pieces of suitable size could be cut off to suit particular places. It would then be possible to produce it without very special forming, leaving the curvature, etc., to be done by the individuals concerned. Several styles would be useful, with nails small or large to suit different classes of castings. Figures 2 and 3 suggest two styles.

The idea is put before the readers with the suggestion that someone with responsibility and opportunity may find in it at least a suggestion for further improvement.

The Ideal Electric Furnace for the Steel Foundry.

In a Paper read at the recent annual meeting of the American Foundrymen's Association, Messrs. F. J. Ryan, E. E. McKee, and W. D. Walker, of the Snyder Electric Furnace Company, Chicago, advocate the single-electrode type of furnace as the ideal electric melting medium for the steel foundry. They contend that a short study of all electric steel furnaces now admitted to be practical will show that the great simplicity in operation and construction of the single-phase or single-electrode furnace eliminates confusing details, and makes it possible for the foundry to change from converter or crucible steel practice to that of electric steel with least loss of time and with least change in the existing organisation.

For foundry work the electric steel furnace converts a charge that consists almost entirely of scrap steel, and it is the grade of scrap available which largely determines the lining to be used. Where the scrap has the same phosphorus and



Cross-Section of Open-roof Type of Electric Furnace.

sulphur content as is desired in the finished product, the acid lining is the most satisfactory and economical in practice; (1) because of the ease and simplicity of operation; (2) because of the difference in cost between acid and basic lining material, and (3) because of the greater heat loss when refining on a basic lining. Where the phosphorus and sulphur must be lower in the finished product than in the charge, or where it is not possible to secure selected scrap the analysis of which is known, the basic lining must be used because only on a basic lining can the phosphorus and sulphur be reduced. In the production of many special steels where no reduction of phosphorus or sulphur or both is necessary, the basic lining is also used because the alloy content can be more readily controlled to the definite points that are desired, and the loss in alloy addition is less.

On the other hand, this reducing of the phosphorus and sulphur on a basic bottom, or holding the heat while making alloy additions and awaiting determinations, adds considerably to the cost of production. The fundamental principle in electric steel furnace construction is the proper application of heat and the reduction of heat losses. Heat may be conserved as well in a basic as in an acid-lined furnace, except for the additional loss due to radiation resulting from the increased time necessary to refine the metal. It is an advantage to have a way to reduce the voltage and the power input while holding the metal for refining, so as to minimise this loss and to save the linings and the steel from overheating. As regards the application of the heat, single-electrode practice differs radically from three-electrode furnace practice in the speed of melting down, but in any event both single and three-electrode furnaces are now operating on both basic and acid linings with commercial results.

A basic lining usually is built up of magnesite, dolomite, magnesite brick, or some combination of these materials. The roof of the furnace is ordinarily of silica brick as in acid practice. It should be possible with any electric steel furnace to change from acid to basic or *vice versa* whenever desired. In such a furnace the foundryman can use the lining best suited to conditions in the scrap market.

The electric steel furnace which produces the finished product in the shortest possible time is the most economical as regards power consumption, for the reason that the actual power needed for the conversion of the charge is the same in all cases. The reason why a single-electrode or single-phase furnace can produce the finished product in a short space of time is because in the single-phase furnace it is possible, with a high voltage and a long arc, to put into the furnace more power within a given period of time.

The simplicity of the electrode control apparatus in the single-electrode furnace has made it possible to develop the open-roof type electric steel furnace, a cross section of which is shown in the cut. This type allows quick charging, preferably by mechanical means, thereby increasing the number of heats and cutting down heat losses during charging. By plastering up the juncture of the roof and the body, and closing up the spout with a sliding door, the furnace can be almost completely sealed up while melting down. There is, of course, no weakness in lining structure with such a furnace. This open-roof type of electric steel furnace has been thoroughly tested, and is presented not as an idea, but as a working and practical design. A number of these furnaces are now in commercial operation.

The question naturally arises whether quick, small heats are an advantage over larger heats at longer periods—in other words, whether the steel foundry can take care of 10 to 12 small heats in 24 hours better than it can take care of six to eight larger ones. This comes down to the practice in the individual foundry, but without a doubt the majority of foundries would find it more convenient to take off five heats per 12 hours or 10 heats per 24 hours rather than three and six heats over the same periods.

The number of heats that can be secured from an electric steel furnace also has an important bearing upon the consideration of the initial price of the equipment. The logical method of measuring the capacity of electric steel furnace equipment is by output over a given period of

time, and not by holding capacity. The furnace which can produce the greatest amount of material over a given period of time is the most economical unit. The single-electrode furnace delivers the quick heats and allows great production.

The authors submit a summary of the results obtained in a ¾-ton single-electrode furnace in the plant of the Gerlinger Steel Casting Company, Milwaukee. The output during January, February, and March, 1916, was 274.23 tons; the total electricity, 146,160 kw.-hours; average kw.-hours per ton, 533; average lbs. per heat, 1,885; average cost per ton of metal in the ladle, £6.

This furnace was lined basic. It was guaranteed to produce three tons of steel per 12 hours with power consumption at the furnace not in excess of 880 kw.-hours per ton of steel. In actual practice the furnace has often produced four heats of 2,000 lbs. for a total of four tons in slightly more than 11 hours. The power consumption on the primary side of the transformer averaged only 533 kw.-hours per ton over the period of three months. A larger single-electrode furnace has since been installed by this company and is now operating with satisfactory results.

A record of a complete day's run in the plant of the Dayton Steel Foundry Company, Dayton, O., showed that in the total time (24 hrs. 40 mins.) the total output was 27,800 lbs.; the average charging time, 22 mins.; average melting time, 72 mins.; average pouring time, 12 mins.; and average time per heat, 106 mins.

This performance, the production of 14 heats of a ton apiece, melting cold steel scrap, over a period of 24 hrs. and 40 mins. is hard to believe. The furnace which made this run is a 1½-ton single-electrode furnace lined acid. The question naturally arises why this furnace was charged with only 2,000 lbs. if it is a 3,000-lbs. furnace. This depends upon the practice in the individual foundry. Some overload and some underload their furnaces. In a similar furnace to that at Dayton, the Crucible Steel Casting Company, Milwaukee, Wis., has charged up to 3,800 lbs., and averages above 3,000 lbs.

The various items that enter into the conversion cost include labour, refractories, electrodes, repairs, accessories, electricity, and overhead.

Labour.—On a furnace up to ¾-ton size only one operator, a melter, should be necessary. On larger furnaces this melter should have an assistant. The common labour will not involve a given number of men, as the work around the furnace is not sufficient to require all the time of the labourers. They will be needed a part of the time for wheeling the scrap, for taking care of the ladles, and for charging the furnace. The size of the furnace, the layout of the foundry, the method of charging, and the method of pouring will all affect this cost.

Refractories.—The life of the roof and linings depends largely upon the care of the furnaceman and the practice in the individual foundry. It is easy to point out isolated cases, such as that of the Crucible Steel Casting Company, Milwaukee, where one roof on an acid-lined single-electrode furnace lasted more than 650 heats. Generally speaking, the roof and side walls of an acid-lined furnace should last from 200 to 250 heats. The bottom of both basic- and acid-lined furnaces should last for a year or more.

Electrodes.—The electrode consumption will also vary according to the care taken by the furnace operator. It is easy to point out other isolated cases, such as the Crucible Steel Casting Company again, where the electrode consumption over several months averaged between 2½ and 3 lbs. to the ton of steel. In practice, the consumption will range from 3½ to 5 lbs. per ton of metal in the ladle.

Repairs and Accessories.—Repairs and accessories are a very small item of the conversion cost. They will add about 1s. 3d. per ton on a ¾-ton furnace, and will gradually decrease as the sizes of furnaces grow larger.

Electricity.—The cost of the power will be affected by whether the furnace is operating on straight melting down or on melting down and refining. The method of charging is important, and the time required dependent upon whether hand or mechanical means are used. The amount of care taken in killing the metal will be another important item. The Dayton Power and Light Company advise as follows: "From all the records we have on the Snyder electric furnace installed by the Dayton Steel Foundry Company, the current consumption has not exceeded 480, in fact, the average is between 470 and 480 kw.-hours per ton of steel." The record at Dayton is on straight melting, on an acid-lined furnace, using good scrap.

Overhead.—The authors' practice is to charge burden in at 20 per cent. to cover interest, depreciation, and taxes. The charge and additions will vary in relation to the market.

The electric furnace, no matter of what type, has now passed beyond the experimental stage and has entered into actual commercial operation, entirely separated from chance or unknown results. The steel foundryman can feel that in interesting himself in the electric steel furnace he is making a step forward in his field and business. Observations of foundrymen and investigations made by men prominent in the steel industry show clearly that steel produced in the electric furnace has a greater strength and a more uniform structure than steel from the converter, open-hearth or crucible. This being so, the foundryman can only ask himself whether or not his business demands a change, and whether or not competition from outside sources, where electric furnaces are being used, is not liable to endanger an established business that he has built up. Manufacturers are basing their purchasing requirements more and more upon figures of specific performance and actual tests. This is tending to eliminate the personal element that business has had for many years. Therefore, it will be a question of quality and price that hereafter will largely determine the volume of business that any steel foundry is liable to obtain. If quality and price are to be the standards upon which the volume of business is to be based, necessarily the foundryman, when he begins the investigation of electric steel furnaces, should convince himself thoroughly that the unit he buys will be the most practical for his requirements, and will produce his steel for the lowest unit cost.

RUST-PROOF COATING FOR IRON.—A rust-proof coating for iron or steel introduced and patented a few years ago by G. F. Wescott (U.S.A.) is in the form of a paint that is applied to the surface of the article to be treated and then baked. The proportions of the ingredients by weight are:—Linseed oil, 25 parts; calcium resinate, 35 parts; manganese borate, ½ part; sugar of lead, 1 part; naphtha, 37½ parts; artificial graphite, 25 parts. The whole is mixed and applied to the steel or iron by brushing, dipping, or other procedure. The article is then baked at 300 deg. F. for one hour and forty minutes. The coating is lustrous and resistant to corrosive influences.

D

Use of Grey-Iron Scrap.

In a paper on "The Use of Cheaper Materials," read by Mr. C. C. Kawin, before the American Foundrymen's Association, the author discusses the economies that may be realised from the use of liberal proportions of stove plate and other scrap in grey-iron foundry mixtures. He points out that silicon is one of the principal elements in a cupola mixture, and demonstrates that the proper proportions of silicon for various classes of castings can be secured when using large amounts of scrap, provided the output is watched carefully and analyses are made regularly. The paper includes the accompanying tables giving details of three all-scrap mixtures and one 75 per cent. scrap mixture that are said to have been used successfully.

I.—*All-Scrap Mixture Containing Stove-Plate and Agricultural Scrap.*

2.00 Per Cent. Silicon in Castings.

Material.	Per charge.	Silicon.	Silicon.	Manganese.	Manganese.	Phosphorus.	Phosphorus.	Sulphur.	Sulphur.
	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.
Returns	200	2.00	4.00	0.55	1.10	0.800	1.600	0.140	0.280
Stove plate	550	2.40	13.20	0.30	1.65	0.900	4.950	0.100	0.550
Agricultural	250	2.25	5.63	0.30	0.75	0.700	1.750	0.100	0.250
Ferro-manganese	5†	—	—	80.00	4.00	—	—	—	—
Total lbs.	1,000	—	22.83	—	7.50	—	8.300	—	1.080
Total silicon, manganese, phosphorus, sulphur		2.28	. —	0.75	—	0.830	—	0.108	—
Loss by oxidation	10%	0.23	25%	0.19	—	—	—	*0.035	—
Net silicon, manganese, phosphorus, sulphur and carbon	—	2.05	—	0.56	—	0.830	—	0.143	—

* Add, from coke. † Weight of ferro-manganese not considered in total.

II.—*Mixture Containing Malleable and Steel Scrap.*

1.50 Per Cent. Silicon in Castings.

Material.	Per charge.	Silicon.	Silicon.	Manganese.	Manganese.	Phosphorus.	Phosphorus.	Sulphur.	Sulphur.
	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.
Returns	150	1.50	2.25	0.55	0.83	0.600	0.900	0.130	0.195
Stove plate	350	2.40	8.40	0.30	1.05	0.900	3.150	0.100	0.350
Agricultural	200	2.25	4.50	0.30	0.60	0.700	1.400	0.100	0.200
Ferro-manganese	5†	—	—	80.00	4.00	—	—	—	—
Malleable	200	0.70	1.40	0.25	0.50	0.200	0.400	0.070	0.140
Steel scrap	100	—	—	0.50	0.50	0.080	0.080	0.060	0.060
Total lbs.	1,000	—	16.55	—	7.48	—	5.930	—	0.945
Total silicon, manganese, phosphorus, sulphur	—	1.66	—	0.75	—	0.593	—	0.095	—
Loss by oxidation	10%	0.17	25%	0.19	—	—	—	*0.035	—
Net silicon, manganese, phosphorus, sulphur and carbon	—	1.49	—	0.56	—	0.593	—	0.130	—

* Add, from coke. † Weight of ferro-manganese not considered in total.

III.—*Mixture Containing Machinery Scrap with Malleable and Steel Scrap.*

1.00 Per Cent. Silicon in Castings.

Material	Per charge.	Silicon.	Silicon.	Manganese.	Manganese.	Phosphorus.	Phosphorus.	Sulphur.	Sulphur.
	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.
Returns	150	1.00	1.50	0.55	0.82	0.425	0.637	0.125	0.187
Machinery scrap	400	2.00	8.00	0.30	1.20	0.700	2.800	0.100	0.400
Malleable	300	0.70	2.10	0.25	0.75	0.200	0.600	0.070	0.210
Steel scrap	150	—	—	0.50	0.75	0.080	0.120	0.060	0.090
Ferro-manganese	5†	—	—	80.00	4.00	—	—	—	—
Total lbs.	1,000	—	11.60	—	7.52	—	4.157	—	0.887
Total silicon, manganese, phosphorus, sulphur	—	1.16	—	0.75	—	0.416	—	0.089	—
Loss by oxidation	10%	0.12	25%	0.19	—	—	—	*0.035	—
Net silicon, manganese, phosphorus, sulphur and carbon	—	1.04	—	0.56	—	0.416	—	0.124	—

* Add, from coke. † Weight of ferro-manganese not considered in total.

IV.—*Mixture Containing 75 Per Cent. Scrap and 25 Per Cent. Pig.*

2.00 Per Cent. Silicon in Castings.

Material.	Per charge.	Silicon.	Silicon.	Manganese.	Manganese.	Phosphorus.	Phosphorus.	Sulphur.	Sulphur.
	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.	Per cent.	Lbs.
Returns	300	2.00	6.00	0.45	1.35	0.600	1.800	0.120	0.360
Machinery	300	2.00	6.00	0.30	0.90	0.700	2.100	0.100	0.300
Steel scrap	150	—	—	0.50	0.75	0.080	0.120	0.060	0.090
Pig, Southern	250	4.25	10.62	0.95	2.37	0.900	2.250	0.030	0.075
Total lbs.	1,000	—	22.62	—	5.37	—	6.270	—	0.825
Total silicon, manganese, phosphorus, sulphur	—	2.26	—	0.54	—	0.627	—	0.083	—
Loss by oxidation	10%	0.23	†15%	0.08	—	—	—	*0.042	—
Net silicon, manganese, phosphorus, sulphur and carbon	—	2.03	—	0.46	—	0.627	—	0.125	—

* Add, from coke. † Lower manganese loss by oxidation due to absence of ferro-manganese in mixture.

Since an iron showing 0.70 per cent. silicon, 0.50 per cent. manganese, 0.325 per cent. phosphorus, 0.150 to 0.200 per cent. sulphur and 3.40 per cent. carbon when poured into a 1-inch square test bar drills very easily with a $\frac{3}{8}$-inch drill, and as these mixtures are higher in silicon and lower in sulphur, they should be sufficiently soft for castings of 1 inch or more in thickness.

Effect of Sulphur on Low-Carbon Steel.*

By Cable R. Hayward.

Sulphur has long been one of the banes of the steel manufacturer, and often no effort and expense have been spared to reduce it in the finished product. This condition is due to a general conviction that in many cases where steels have failed in service, sulphur has been the cause. But there has been a growing feeling in recent years that the verdict against sulphur has been unnecessarily severe.

It is now contended that high sulphur is not harmful provided the steel is not otherwise poor owing to insufficient reduction in the blast furnace. The presence of a moderate amount of sulphur is desirable for the easier machining of the steel. The low-sulphur material "drags" and the production of a smooth surface is very difficult. A slight increase in sulphur enables the machinist to produce a smooth surface without difficulty. It becomes, therefore, highly important that the sulphur controversy should be settled, and if the presence of sulphur is proved to be harmless the ban on it should be lifted.

Among the recent papers on the effect of sulphur on steel is one by Dr. J. S. Unger, manager of the central research bureau of the Carnegie Steel Company. The results of an exhaustive series of tests are given, and the conclusion is:—

"The author does not advocate paying no attention whatever to sulphur content in steel, but believes firmly that a steel containing as much as 0.1 per cent. is not necessarily bad, and that it will show little, if any, difference in quality when compared with the same steel of much lower sulphur, other conditions being the same."

The present investigation was undertaken at the suggestion of Mr. Annan, of the Rhode Island Tool Company, who co-operated by furnishing the steel and machining the specimens. The results are presented as a contribution to the general knowledge on the subject.

The Steels Used.—It was planned to use three steels of different sulphur content, but with the other elements the same. The manganese was an exception, however, for with this element a part is present in the form of MnS existing free in the steel and the remainder is dissolved in the steel. It is evident, therefore, that the manganese should vary, but that the amount in excess of MnS should be constant in the different steels. Two bars of each grade were required to furnish sufficient specimens. The analysis of the six samples showed the following variations in the percentages:—Carbon, 0.17 to 0.18; manganese, 0.55 to 0.80; excess manganese, 0.48 to 0.55; phosphorus, 0.006 to 0.011; silicon, 0.01 to 0.03; sulphur, 0.038 to 0.152.

* Abstract of a Paper to be presented at the meeting of the American Institute of Mining Engineers in February, 1917.

Tensile Tests.—There was not sufficient variation in the results of the tensile tests to make an effective graph, but the subjoined table summarises the figures by giving the order in which they occur from high to low. The designations *L*, *M* and *H* refer to low, medium and high sulphur percentages.

Summary of Tensile Tests showing Rank.

	Yield point.			Breaking load.			Elongation.			Reduction of area.		
	L	*M*	*H*	*L*	*M*	*H*	*L*	*M*	*H*	*L*	*M*	*H*
Quenched in ice water	1	3	2	2	3	1	3	1	2	3	1	2
Cooled in still air	2	1	3	2	3	1	1	2	3	2	1	3
Cooled in furnace	2	1	3	3	2	1	1	2	3	2	3	1
Reheated to 300 deg.	3	1	2	2	3	1	3	1	2	3	1	2
Reheated to 400 deg.	3	1	2	3	2	1	1	2	3	1	2	3
Reheated to 500 deg.	3	2	1	3	2	1	1	2	3	1	2	3
Reheated to 600 deg.	3	2	1	3	2	1	1	2	3	1	2	3

Shock Tests.—After concluding the tensile tests, it was thought desirable to determine the effect of varying sulphur content on specimens subjected to shock on a Charpy machine. After heat treatment in sets of three, the specimens were machined, notched across one side, and broken. The Charpy machine consists of a heavy pendulum which drops from a fixed height, strikes the specimen supported at each end, and breaks it at the notch.

Conclusions.—The table shows that the high-sulphur steel has for each treatment the highest breaking load while the yield point ranks first for two treatments, second for three and third for two. From this we may conclude that the sulphur does not lower the tensile strength. The figures for elongation and reduction of area show that there is little difference in ductility between the low- and medium-sulphur steels, but the ductility of the high-sulphur steel is slightly lower than the other two for most of the treatments.

The average figures for the shock tests, except for the air- and furnace-cooled specimens, are highest for each treatment in the case of the low-sulphur steels and lowest for each treatment for the high-sulphur steels. The widest difference appears in the steels which have been quenched and reheated.

The tensile tests are not unfavourable to steels with moderate amounts of sulphur, while the shock tests show a decided falling off in strength as the sulphur increases.

Further light might have been thrown on the subject by making alternating stress or fatigue tests. It would have been important to learn whether the results confirmed the tensile or the shock tests. Unfortunately, however, the stock of steels used in the previous work was exhausted.

Restrictions on Manufacturers.—The Press Bureau has issued the following announcement:—

The Minister of Munitions, in the exercise of his statutory powers, has required all persons, firms, and companies engaged in the manufacture of cranes, aerial ropeways, capstans, conveyors, grabs, elevators, hoists, lifts, runways, shear legs, transporters, travellers or winches, whether operated by steam, electric, hydraulic, pneumatic, or hand power, not to carry out without a permit issued under his authority, in any factory, workshop, or other premises, any work consisting of the manufacture, assembling, or erection of any of the above-mentioned articles except under:

(a) Orders received from or in connection with work for the Admiralty or War Office;

(b) Orders of a value not exceeding £50 required for war work;

(c) Orders which have already been sanctioned by the Ministry of Munitions as Class "A" work.

Queries and Replies.

Leaky Castings.

There has lately come under my notice some trouble with a steam boiler-feed check valve box casting. Four castings were made altogether, and three of them stood 600 lbs. hydraulic pressure when tested in the shop, but leaked when fixed to a steam boiler working at 120 lbs. steam pressure. Can you tell me why this should be so? I would like to get some information which would obviate such trouble in future. What do you consider the right mixture for such a casting?—" D. R."

Phosphor Bronze Trouble.

Reply.—Regarding the query in the last issue, better results would be obtained by " R. W. W." by casting on the flat, and gating at each end. One or two risers could be allowed. The low temperature at which this alloy should be poured is all against a sound casting of the description given when poured vertically or semi-vertically. Not only so, but the flat position gives a more uniform shrinkage. It would be interesting to know how " R. W. W." eventually gets over the difficulty.—" P. B."

Reply.—The following is my opinion as a working foreman:—

There are many little items that will cause gas cavities, especially at the top end. One is choked or stiff vent, the air not escaping freely from core. The defects will show even on the outside skin, also at the top. This is overcome in many cases by making the pattern 1 foot longer, and cutting the surplus off the casting. If the pattern cannot be altered, high-pressure risers on top, flowing over into a basin, will enable the metal to clear itself of gases.

I have found that cold metal, or over-cooled metal, will show these defects in phosphor bronze. Personally I advocate casting this class of work on end to procure solidity and cleanness. It is advisable to cast the metal with a little more than the average heat, but to cast slower.

To solve phosphor-bronze troubles not only one item has to be studied, but everything concerned, core, mould and metal—even black-washing, if overdone, will harden and close the surface skin of a mould to such an extent that the metal won't lie peacefully. Long hanging cores are most difficult, having one end only for gas escape.

Cupola-melted metal should answer for this class of work if properly mixed. If using virgin metal it is best to melt the composition in crucibles; then, having run the metal into the ladle, pour in the composition and stir well. This method gives better results than putting in the composition otherwise.—A. Purves.

TRANSACTIONS OF THE AMERICAN INSTITUTE OF METALS.—The ninth volume of the " Transactions " of this Institute has been forwarded from the offices, Buffalo, New York, U.S.A. It covers the September, 1915, meeting of the Institute, and contains very many papers and discussions of foundry interest, some of which we have already published in abstract.

Crude Oil for Cupola Melting.

Mr. Bradley Stoughton, in an American contemporary, describes a method of using crude oil for cupola melting, and saving thereby three parts of the quantity of coke which is generally burned in the ordinary process. The oil and air are conveyed to an ignition chamber in the cupola by two pipes. The oil flame is started in the ignition chamber and enters the cupola in contact with the coke bed, which is maintained in an incandescent state by an independent supply of air admitted through tuyeres underneath the ignition chamber. Peepholes at the ends of the tuyeres and the ignition chamber enable one to observe the combustion of oil and coke, and independent valves on each of the different pipes enable the air to be adjusted to give perfect combustion of oil in the ignition chamber and the necessary amount of combustion of the coke through the tuyeres. Where coke is dear and crude oil is cheap, it is obviously desirable to have the minimum possible consumption of coke which will maintain the bed in an incandescent state, and this is accomplished by adjusting the valves connected with the tuyeres.

The cupola is first filled with coke up to the melting zone, and the coke is brought to a state of incandescence in the usual way. The amount of coke used and the method of getting it red hot is the same in the oil process as in the usual coke process. On top of the bed the first charge of iron is then placed, which also is the same depth as in coke melting; then comes a layer of coke which is only one-quarter the amount ordinarily used. On top of this comes another layer of iron of the usual weight, then a layer of coke of one-quarter the usual size, etc. The bottom bed of coke is kept red hot at all times by its own combustion, but that combustion is very much less than in the ordinary cupola, because that heat is not wanted to melt the iron; merely sufficient heat is wanted to maintain the bed at a bright red colour. The layers of coke coming down from above are just sufficient to replenish this bed and maintain it as in the ordinary cupola process. The oil is atomised into ignition chambers surrounding the cupola, and is there mixed with air for its combustion. The flame from the burning oil enters the cupola and comes into contact with the bed of coke by which its combustion is hastened and completed. The result is an intensely hot oil flame by which the bulk of the melting is done. The operation is similar to the ordinary coke melting operation, the principal difference being that the temperature is under better control by means of controlling the oil and air admitted. When once adjusted, the oil flames need very little further attention.

A REMEDY FOR SLIPPERY IRON PLATE FLOORS.—A writer in the " American Machinist " describes the following method for dealing with slippery floors:—" We take a small amount of powdered sal-ammoniac, which is used as a corroding agent in our work, and mix it up thoroughly with a large quantity of fine sand. This mixture is sprinkled over the floor so that all parts are covered, and the whole mass is watered, using an ordinary sprinkling can, and left to lie overnight. In the morning the sand is swept up, and the rust coating will last for several weeks after which the process is repeated. We found that this method involved less time and cost, and was more effective in eliminating danger from slippery iron plate floors than any other."

Non-Ferrous Notes.

Cadmium Alloy for Bearings.—Among the very numerous alloys introduced for bearings is the following :—Cadmium, 45 per cent. ; zinc, 45 per cent. ; antimony, 10 per cent. This was the subject of a German patent, and was claimed to have a very low coefficient of friction and to cast well.

Brass for Gas Cocks.—The metal for this work is required to cast well and machine well ; and a suitable mixture is 20 parts copper, 8 parts zinc and 1 part lead, the percentages being respectively about 69, 27.6 and 3.4. An increase in the zinc content renders the metal harder to machine, while a reduction makes it rather too soft for the work in question.

Silver-White Alloy.—A white alloy which closely resembles sterling silver is composed of 50 per cent. copper, 25 per cent. silver, and 25 per cent. nickel. If if is intended for rolling, the addition of about 0.1 per cent. manganese as a deoxidiser is necessary, this being added as 30 per cent. manganese-copper. The metals should be put into a crucible together and melted under borax. The alloy resulting can be rolled into sheet like sterling silver, and is fairly resistive to corrosion.

Manganese Bronze Substitute.—A mixture which is said to serve most of the purposes for which manganese bronze is used, is composed of 55 per cent. copper, 44 per cent. zinc, 0.5 per cent. tin, and 0.5 per cent. aluminium. If, however, for 5 per cent. of the copper be substituted that amount of 30 per cent. manganese-copper, the mixture can be made into a real manganese-bronze, or more accurately manganese brass. This mixture will show a tensile strength of upwards of 50,000 lbs. per sq. in.

Gunmetal for Hose Couplings.—For this work the standard 88-10-2 copper-zinc-tin gunmetal is the best, but price considerations at ordinary times often make it desirable to change the mixture. A stiff metal, to avoid bending, is necessary, and a suitable mixture is as follows :—Copper, 65 per cent. ; zinc, 30 per cent. ; tin, 2 per cent. ; lead, 3 per cent. This metal machines well, and gives very good results. If the tin is omitted a brass is obtained which is much more liable to distort or bend on being dropped or in use, and result in a badly-fitting coupling.

Brazing Brass.—This term is usually applied to yellow brasses, of composition ranging from 80 to 85 per cent. copper and 20 to 15 per cent. zinc, which will stand brazing with ordinary yellow brazing solder (50 copper, 50 zinc) without melting or cracking. These defects are liable with the brasses of low copper content, such as 60—40, on account of their lower melting points. If tin is present in the brazing brass cracking is liable to occur, while lead also should be absent. The 80 copper, 20 zinc mixture is yellow in colour, but when the zinc is reduced to 15 per cent., with 85 per cent. copper, the metal has an orange tint. The melting point of the lower zinc mixture is, of course, slightly the higher of the two, and hence it is the more suitable, unless the colour is a matter of importance.

Malleable Nickel.—Nickel of 98 to 99 per cent. purity can be kept malleable for working if melted in clay-lined crucibles and suitably deoxidised with about 1 per cent. of manganese to secure soundness. Graphite crucibles should not be used for the work, as the nickel tends to absorb the carbon, which renders it hard and unfit for rolling. If desired, a solid clay crucible may be used. The manganese can be added to the pot with the nickel, but no charcoal should be used as a flux or protection, as that again would introduce carbon with the above-mentioned trouble of hardness. The oxidation of the nickel produces a slag which acts as a protection from excessive oxidation. Melters of nickel for sheet rolling usually prefer an open mould to a closed one, on account of the rapid chilling of the metal rendering casting in closed moulds difficult.

Machining Aluminium Alloy Castings.—In machining castings of aluminium and its alloys a difficulty is frequently encountered by reason of the chips becoming so firmly embedded between the teeth of milling cutters and tools that they cannot be removed with a stiff brush, and the machine has to be stopped for their removal. This necessitates the use of a lubricant. Oil does not prove suitable, but soapy water gives good results, although it leaves a dull surface. The best cutting lubricant is kerosene, which gives a bright finish when the cutting tools are properly ground. The cutting edges of all tools should have sharp, square corners or edges, and there should be plenty of cutting relief or clearance. For milling flat surfaces, it is best to use end mills rather than cylindrical cutters. These mills will cut best if a high cutting speed is used with a moderate feed. A cutting speed of about 300 ft. per minute is considered by some users to be suitable.

Sulphur in Brass Castings.—The presence of sulphur in brass castings appears to result in dirty metal, blowholes, and dark skin on the surface. In the opinion of one authority many failures that are credited to the presence of oxygen are really due to sulphur. It is stated that in the most careful crucible melting in coke-fired furnaces, the metal will take up from 0.02 per cent. to 0.05 per cent. of sulphur. Copper has the greatest affinity for sulphur of the foundry's metals, apart from manganese, and it tends to absorb it if brought in contact with sulphur-laden gases. Sulphur in such case would accumulate each time the metal is melted, and accounts for the dark skin on re-run castings, as compared with those of first-melt metal. The claim that scrap is not as good as new metal may have a direct connection with the sulphur content, as much of the scrap on the market has been melted over many times. A further effect of sulphur is to make the castings " red short " and liable to crack in the mould.

Type Metal for Machines.—Metal for type-casting by means of linotype or similar machines must melt at as low a temperature as possible ; it must be quite fluid when melted, as it has to pass through a small orifice into the mould, and thick metal clogs the gate ; it must be hard so that the letters will not become flattened in the press ; and it must fill the mould so that the letters will come out clear and sharp. Ordinary type metal will not answer the purpose, as it contains too much antimony, causing the melting point to be too high and the metal to chill in passing through the gate. The following mixture is suitable and extensively used :—Lead, 83 per cent. ; antimony, 12 per cent. ; tin, 5 per cent. Antimonial lead is generally used, as the antimony which it contains is cheaper than pure antimony. If desired, the following mixture, using antimonial lead, may be employed :—Lead, 35 per cent. ; antimonial lead, (20 per cent. Sb.), 60 per cent. ; tin, 5 per cent. Tin is essential in these mixtures, as lead and antimony alone will not run sufficiently freely. The " slugs " or lines of type, of course, are melted over again after use.

Pouring Temperatures in Casting Valves.—Steam-metal valve castings require hot pouring. If the metal is poured dull the casting is not good, but is liable to develope leakage under pressure. If crucibles are not used for melting the metal is apt to become chilled before the flasks are poured. In crucible pouring the metal is usually hotter. A typical defect from dull pouring is leakage near the gate. In such cases an examination of the fracture under a magnifying glass will generally show that instead of the usual fibrous fracture of good steam metal, the leaky portion has a drossy appearance, showing that oxide has entered the metal and has not been able to clear itself. In explanation of the apparently more rapid oxidation of dull metal than hot metal it has been suggested that at a low temperature oxide of tin and copper form as well as oxide of zinc. At a higher temperature, the zinc reduces the oxide of tin and copper and the zinc oxide is the only one to remain. As the zinc volatilises it envelops the stream with a reducing or non-oxidising atmosphere. Whether or not this is right, it is a fact that valves poured too cold leak, while those poured at a higher temperature do not. Remelting such leaky castings and repouring at a higher temperature will often give quite sound castings.

Trade Talk.

THE DUTCH GOVERNMENT has prohibited the export of iron and steel and of alloys of these metals, unless used as packing.

A ROYAL PROCLAMATION was signed last month adding aluminium powder to the list of articles, the import of which is prohibited.

A SWANSEA firm are reported to have acquired the old Siemens' steelworks at Landore in order to start the smelting of zinc concentrates.

THE liquidator of the Belhaven Engineering & Motors, Limited, is paying a first dividend of 10s. per £ to the ordinary creditors.

THE WARWICK MACHINERY COMPANY (1908), LIMITED, is being wound up voluntarily, with Mr. A. Clements, 83, Cannon Street, London, E.C., as liquidator.

MR. H. HOPE, engineer and hardware manufacturer, lately carrying on business at 17, Paradise Street, Wolverhampton, has been adjudged bankrupt.

MR. W. H. ELLIS, managing director of John Brown & Company, Limited, was at Sheffield, last month elected for the third year in succession Master Cutler.

MESSRS. PARNALL & SONS inform us that their head office and works for aircraft work are situated at Mivart Street, Eastville, Bristol, where all communications should be sent.

A FIRST and final dividend of 1s. 0¾d. in the £ is being paid by M. E. Aspinall, trading as Joseph Aspinall & Company, engineers and ironfounders, Bella Street, Daubhill, Bolton.

MR. GEORGE ELLISON, manufacturing electrical engineer, etc., of Birmingham, has removed his Yorkshire branch office from Sheffield to Standard Buildings, City Square, Leeds.

THE partnership heretofore subsisting between Messrs. F. Powell and H. Powell, carrying on business as engineers, at New Denham, under the style of F. & H. Powell, has been dissolved.

MR. F. BAILEY, M.Inst.C.E., who has accepted office for another year as President of the Association of Engineers-in-Charge, gave his presidential address on the progress of the engineering industry after the war.

THE assets at Calais of Brampton Brothers, Limited, amounting to £30,000, have been sold to a separate company, Brampton Brothers (Calais), Limited, the consideration being an allotment of 30,000 fully-paid shares.

IN connection with the paragraph which appeared in our last issue, Joseph Sankey & Sons, Limited, Wellington, Shropshire, inform us that inquiries referring to goods manufactured at their Bilston works should be sent to Bilston.

DURING the last fifteen months the Master Cutlers' Company, of Sheffield, have issued 104,000 certificates in respect of the export of iron and steel products. Sixteen members are now serving on the signing committee of the company.

THE Minister of Munitions announces that he has made further Orders under the Munitions of War Acts, 1915 and 1916, under which 107 additional establishments have been declared controlled establishments. The total number of controlled establishments is now 4,319.

THE partnership heretofore subsisting between Messrs. E. Lumb and A. Standeven, carrying on business as machine tool makers, at Green Mount Works, Hanson Lane, Halifax, under the style of E. Lumb & Company, has been dissolved. Mr. Lumb will continue the business.

DR. WERTHEIMER, Dean of the Faculty of Engineering at the University of Bristol, has suggested a modified "sandwich" system of training young engineers—that is, University classes in winter and works experience in summer—adapting the Scottish system to the conditions of an English University.

THE ENGINEERING IMPROVEMENT COMPANY, LIMITED, 4a, First Avenue Hotel Building, High Holborn, W.C., has made arrangements with Vickers, Limited, for the manufacture of the "Perfloc" locknuts, and all inquiries in regard to the same should in future be made to the last-named concern at Vickers' House, Broadway, Westminster, S.W.

THE FARADAY SOCIETY will hold a general discussion on "Refractories" at their first autumn meeting, the date of which is provisionally fixed for Wednesday, November 8, 1916. The discussion will be presided over by Sir Robert Hadfield, President of the Society, and the opening Paper will be read by Dr. J. W. Mellor, of Stoke-on-Trent.

THE STANDARD SHIPBUILDING COMPANY, LIMITED, has not waited until the site is completely prepared before starting shipbuilding operations, but has commenced constructional work, and a start has been made on ships of comparatively small dimensions. Preparations for the erection of residences for the officials of the new company are now completed, and the plans have been before the local council.

THE NATIONAL TIME RECORDER COMPANY, 5, Blackfriars Road, London, S.E., advise us that owing to the increasing demand for time recorders of British manufacture they have extended their manufacturing premises by taking an additional factory occupying a floor space of over 3,500 superficial feet at 88, 89, and 90, Upper Ground Street, almost adjacent to the present premises.

MESSRS. WILFRED ROGERS & COMPANY, metal merchants, Audrey House, Ely Place, London, E.C., inform us that, owing to the increase in their business, they have, with the approval of the Treasury, converted their business into a private limited liability company, under the name of Wilfred Rogers & Company, Limited. Mr. A. W. Rogers and Mr. G. H. Rogers are the first directors.

MESSRS. STEPHENS & COMPANY, silica brick manufacturers, Kidwelly, are about completing an entirely new and up-to-date works which they have been erecting for the last six months, at the special request of the Ministry of Munitions. The works are alongside the Company's present works, and the total area covered by their silica brick-making establishment is now about seven acres. Once the new works starts the output of silica bricks will be about 40,000 per day.

THE firm of Caird & Company, Limited, is in future to be closely associated with Harland & Wolff, Limited, of Belfast and Govan. There will be no real change in the management of the Greenock concern, the present directors, Mr. P. T. Caird and Mr. Arthur Caird still remaining directors of the company. Mr. J. W. Kempster, one of the managing directors of the Belfast company, will join the board of Caird & Company, Limited.

SINCE the beginning of the war it has been found necessary for Vickers, Limited, to make great extensions to their works at Barrow-in-Furness, and now a still further development has been decided on. They have purchased from the Furness Railway Company a large tract of land bordering on Walney Channel, on which they propose to build mercantile tonnage. This plot of land has a frontage of about 1,500 ft. to Walney Channel, and it is calculated that at least 15 vessels in course of construction can be laid down at one time.

THE adoption of welfare schemes is now becoming fairly general in the factories of Great Britain. The latest firm to experiment in the direction of making their works more attractive to their employés is Needham Brothers, Limited, of Sheffield, and the scheme is being highly appreciated. A comfortable mess-room containing current literature has been provided, and the factory is closed for an hour at dinner time, so that the operatives can spend a little time in reading after the meal. Overalls have also been supplied to the men, lockers to contain their outer garments, and ample lavatory accommodation.

A MEETING of the Advisory Committee of the Board of Trade on Commercial Intelligence was held last month, Sir H. Llewellyn Smith presiding. The Comptroller-General of Patents, Designs and Trade Marks and Mr. G. P. Harben also attended the meeting. Among the matters considered by the committee were proposals for the amendment of the existing law

relating to patents and designs; proposals for the despatch of a special commercial mission to investigate the conditions and prospects of trade in Spain and Portugal; and questions relating to the promotion of British trade with Russia and Italy and the employment of foreigners as commercial travellers.

THE members of the Nottingham Society of Engineers opened their new session with a well-attended meeting at the Welbeck Hotel last month, the president, Mr. W. R. Bates, being in the chair. Mr. C. J. Hofton was in the vice-chair. There were six papers, as follow: "Gas Engine Troubles," by Mr. T. L. F. Bates; "Collection and Utilisation of the Water Condensed in Steam Ranges and Appliances," by Mr H. H. Hayes; "Bearings," by Mr. A. Beeston; "Moulders, Engineers, and Pattern-makers," by Mr. J. Stevenson; "Boiler-house Accessories and Maintenance," by Mr. D. Rushworth; "Gas Engine Troubles," by Mr. F. W. Sisson. A discussion followed the reading of the papers.

IN the latest of the series of memoranda issued by the Health of Munition Workers Committee the subject of juvenile employment is discussed, and proposals are submitted for lessening the strain imposed on boys and girls by the existing labour conditions in munition works, and generally for safeguarding their physical and moral welfare. It is urged that at the present time, when the war is destroying so much of its best manhood, the nation is under special obligation to secure that the rising generation shall grow up strong and hardy, both in body and character. It is necessary to guard not only against immediate breakdown, but also against the imposition of strains which may stunt future growth and development.

NOTICE is given that the names of the undermentioned companies have been struck off the Register of Joint Stock Companies, and such companies are dissolved:—Carlton Engineering Company, Limited (registered September 29, 1910); Cone-Jackson Engineering Company, Limited; Hall's Iron Company, Limited; Molybdenite, Limited; Southgate Engineering Company, Limited; Swansea Dry Docks & Engineering Company, Limited; Atlas Anti Friction Metal Company, Limited; Becker Steel Company, Limited; Caldwell & Scarborough (Engineering), Limited; Chadwick Engineering Company, Limited; Lancashire Tool Company, Limited; Liddell Engineering Company, Limited; and the Vortex Engineering Company, Limited.

IT is officially announced that, with a view to improving the organisation for assisting British trade by collecting and disseminating commercial information, the President of the Board of Trade has decided to amalgamate the Commercial Intelligence Branch and the Exhibitions Branch of the Board, and has appointed Sir William Clark, K.C.S.I., C.M.G., to be Comptroller-General of the combined department, which will be known as the Department of Commercial Intelligence. Mr. Thomas Worthington, who has just retired from the post of Director of the Commercial Intelligence Branch, under the age limit, has consented, at the request of the President, to assist the department in a consultative capacity as Commercial Adviser.

ARRANGEMENTS for the British Industries Fair, which will be held in Glasgow next spring simultaneously with the kindred event in London, are rapidly taking shape, and present prospects point to a highly successful exhibition. The fair is being promoted by the Corporation of Glasgow under the auspices and with the support of the Board of Trade. It is not only intended to reproduce in these British Industries Fairs the main features of the famous Leipzig Fair, which has done so much for German trade; the ideal which the Board of Trade is striving to attain in encouraging these exhibitions is virtually the economic independence of the Empire. Firms exhibiting at the fairs must be either home or overseas British manufacturers.

THE 1916 scholarship of the North-east Coast Institution of Engineers and Shipbuilders has been awarded to E. V. Telfer, an apprentice in the service of Wm. Gray & Company, Limited, West Hartlepool. The scholarship is valued at £50 per annum, and is tenable for two years. The council, believing that the time has arrived for making the subjects of the Institution's scholarship examination more comprehensive than hitherto, have decided that the syllabus of future examinations shall be:—(1) English, (2) English History and geography, (3) Latin, Greek, French or German (one of these four), (4) extra mathematics, (5) and (6) either experimental science and mechanics, or any two of the following: Chemistry; physics; mechanics.

IN addition to the awards announced in April for papers read at the meetings, the council of the Institution of Civil Engineers have made the following awards for papers published in the proceedings without discussion during the Session 1915—1916:—Telford Premiums to Messrs. Hubert Mawson (Liverpool), T. W. Keele (Sydney), R. W. Holmes (Wellington, N.B.), W. Fairley (London), J. M. Greathead (Johannesburg), T. C. Hood (Manmad, India), and J. P. Ball (London); the Manby Premium to Mr. W. C. Cushing (Pittsburgh, U.S.A); and the Crampton Prize to Major C. E. P. Sankey, D.S.O., R.E. (London). The Indian Premium for 1916 has been awarded to Sir John Benton, K.C.I.E. (Eastbourne).

THE announcement is made by the Board of Trade that in future the Labour Exchanges under their control will be termed "Employment Exchanges," a title which corresponds more accurately to their present functions. The scope of the Employment Department of the Board of Trade will be enlarged so as to include in addition to Employment Exchanges and Unemployment Insurance Trade Boards and certain other matters relating to labour. Mr. W. H. Beveridge, C.B., will continue to be the head of the enlarged Employment Department. The President has appointed Mr. C. F. Rey (hitherto general manager of Labour Exchanges) to be Director of Employment Exchanges, in succession to Mr. Beveridge, with the acting rank of an assistant secretary.

AN agreement has been arrived at by which C. and H. Crichton, Limited, Liverpool, and James Little & Company (Glasgow), Limited, acquire the business of Hawthorne & Company, Limited, shipbuilders and engineers, Leith. Little & Company have associated with them in this purchase a private shipowning company of which they are the managing agents, and J. Crichton & Company, Limited, are jointly interested with their associated firm. The transfer of the business will be completed shortly. The premises of Messrs. Hawthorne comprise a well equipped engine works and shipbuilding yard, with seven building berths and excellent launching facilities. Under contemplated arrangements various sized steamers up to about 370 ft. in length can be laid down.

ACCORDING to Mr. C. A. Mercer, chairman of the British Laboratory Ware Association, Limited, which comprises seventeen firms dealing in chemical and scientific apparatus, the Association, immediately on the outbreak of war, combined to consider what steps could be taken to induce manufacturers to replace, if possible, German porcelain. They realised this might be done if they united and could assure manufacturers of a market for their output, with the result that not only Messrs. Doulton & Company, but Messrs. Macintyre & Company, of Burslem, and the Worcester Royal Porcelain Works succeeded in producing a porcelain suitable for laboratory purposes. Every encouragement and commendation should be given to these firms for the successful results of their praiseworthy efforts to compete with the Germans.

As noted in these columns a few months back, the management of the Imperial Institute has been transferred to the Colonial Office, with the result that a new executive council was elected. This new body, of which Lord Islington is chairman, has lost no time in getting to work. A Committee on Mineral Resources has been appointed, and is at present engaged in collecting and co-ordinating information respecting the occurrence, production, and uses of minerals throughout the Empire. This committee includes Lord Rhondda, Sir Robert Hadfield, Professor J. W. Gregory, Dr. F. H. Hatch, Mr. G. T. Holloway, and

representatives of the Home Office and the Board of Trade. The new council are endeavouring to render the Institute a reany effective centre for information respecting the production, nature, and uses of the raw materials of every part of the Empire.

Four more Rennerfelt electric steel furnaces for installation in the United States have lately been ordered as follows:—Ducas & Company, New York, a 3-ton furnace, 600 kw., for making steel castings and ingots; Maynard Steel Castings Company, Milwaukee, Wis., a ¾-ton furnace, 300 kw., for making steel castings; the Acieral Company of America, Newark, N.J., a 300-lb. furnace, 50 kw., for making special alloys; J. Leslie Rodgers, of Philadelphia, a ¾-ton furnace, 200 kw., for making tool steel. This company will also install ten small furnaces of special size for making ferro-tungsten. Besides these American installations orders for six Rennerfelt furnaces have been placed in other countries in the last few weeks, all to be used for making steel. The total number of Rennerfelt furnaces installed or contracted for is now seventy-six, of which eighteen are in the United States, not including the ten small ones, mentioned above, for making ferro-tungsten.

In the Companies Winding-Up Court, last month, Mr. Justice Neville heard an application by a shareholder in the Consolidated Diesel Engine Manufacturers, Limited, for an order against the liquidator of the company to pay him a first return of 10d. a share on 4,617 shares. Counsel for the applicant said that his client had been a director of the company. A winding-up order was made on July 7, 1914, and a liquidator appointed in the following October. In August, 1915, a dividend of 20s. in the £ to creditors was declared. Plaintiff was also a creditor, and the liquidator claimed to retain the amount of that debt. The registrar made an order for payment. But on May 31, 1916, the liquidator obtained an order ex parte entitling him to retain the first return to shareholders in respect of the share holding by plaintiff on the ground that the company had claims against him for misfeasance. His Lorship dismissed the summons.

An interesting programme was opened for the winter session by the Junior Institution of Engineers, 39, Victoria-street, S.W., recently, when Mr. E. Eade opened the series of informal discussions, taking for his subject "Stability and Use of Cranes under Working Conditions." During October similar lecturettes will be given on "Principles and Applications of the Oil Engine" by Mr. W. H. Abrahams: and "Time Saving as a Science" by Mr. A. H. Stanley. The ordinary monthly meeting was held on Wednesday of this week, when Mr. Frederic H. Taylor read a paper on "Industrial Lighting by Electricity." A special series of five lecturettes will be given on alternate Friday evenings from October 20 by Mr. E. Fiander Etchells on:—A common-sense notation for engineers: the practical use of units in the evaluation of formulæ: how to memorise formulæ: logic of the differential and integral calculus: and practical and illustrative examples of the application of the newer concepts.

In the Patents Court last month application was made for licence to use two German patents for the manufacture of spelter in connection with the Government's purchase of zinc from Australia. The applicants were the Share Guarantee Trust, Limited, who own practically all the shares in the Swansea Vale Spelter Company, Limited. It was explained that before the war the Swansea Company belonged to Aron Hirsch und Sohn, who put in their latest plant, but when the Share Guarantee Trust took over the company 100,000 newly-created preference shares were given to the Germans, which the Public Trustee had now seized. Over £50,000 was being spent on immediate additions to the Swansea works to make the experiments covered by those patents, and if all went well it was proposed to make important developments through the flotation of a new company for dealing with some of the Government's large purchase of zinc concentrates from Australia. The Controller said licences would be granted to the applicants.

Legal.

Railway Rates for Scrap.

The Railway and Canal Commission Court, on October 12, delivered judgment in the actions brought by Thomas W. Ward, Limited, against the Midland Railway Company for a declaration that the railway company had illegally raised the rates for the carriage of scrap files and propeller shafting removed from a ship and consigned as scrap to Sheffield. The railway company's reply was that, as both were commercially dealt with afterwards, they were not scrap, and could not be carried as scrap.

Mr. Justice Lush found that the company had no right to seek to make a differentiation because the applicants chose to sort out some of the old files bought and sell them abroad as old lines and not scrap. They were sold and carried to a Swansea firm as scrap, and must be carried at scrap rates. The declaration for which Messrs. Ward asked must be made. The other commissioner agreed.

Munition Making.

The Ministry of Munitions makes the following announcement:—

As a result of the examination of the question of Sunday work in its relation to the maintenance of output, the Minister of Munitions has decided so far as possible to prohibit Sunday work in establishments in which munitions work is carried on.

As a first general step, he has accordingly issued a general instruction prohibiting as far as possible Sunday labour throughout the North-East Coast on and after October 8.

Exceptions are, however, made in cases where the work is necessarily of a continuous nature, or where the repair to plant and machinery can only be performed during the week-end.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Armstrong, J. Metallurgy of iron and steel. 13,698. September 27.

Ashworth, E. C. J. Casting steel ingots, etc. 13,258. September 19.

Barr, G. Foundry, etc., drying-stoves. 13,166. September 16.

Bedford, A. H. Apparatus for removing scale, etc., from surface of forgings and castings. 13,644. September 26.

Belliss & Morcom. Impregnating and coating metals with other metals. 13,568. September 25.

Bibbings, G. H., and Coombs, R. N. Compound for treatment of fire-bricks, furnace linings, etc. 13,771. September 28.

Brayshaw, E. R. and S. W., and Yates, H. J. Furnaces. 12,941. September 13.

Duckham, A. M. Annealing-ovens, etc. 13,587. September 25.

Hall, I. Gas-fired furnaces. 13,318. September 20.

Heyl, G. E. Liquid fuels for firing furnaces and for high-compression oil engines. 14,148. October 5.

Jarvis, G. A. Manufacture of iron and steel. 13,581. September 25.

Keith, G. and J. Crucible furnaces. 13,060. September 14.

Kilby, J. N. Casting ingots, etc. 12,868. September 12.

Kluijtmans, C. Testing-machine for hardness of case-hardened steel. 12,865. September 12.

Lalbin, E. L. Cold process for obtaining galvanic deposit of aluminium, etc. 13,523. September 23.

Landtmeters, J. C. Electric resistance furnaces. 13,593. September 25.

Lund & Company, A. Hardening compounds 13,797. September 28.

Morris, A. W. Forged castings, and method of making same. 12,907. September 12.

Robinson, J. Charging cupolas. 13,201. September 18.

Seligman, R. Method of protecting aluminium or its alloys from corrosion by sea-water, etc. 13,831. September 28.

Southwick, P. Furnaces 13,174. September 14.

Williams, P. Method of protecting aluminium or its alloys from corrosion by sea-water, etc. 13,831. September 28.

Wright, D. Liquid-fuel-heated furnaces. 13,548. September 25.

Yates, H. J. Furnaces. 12,941. September 13.

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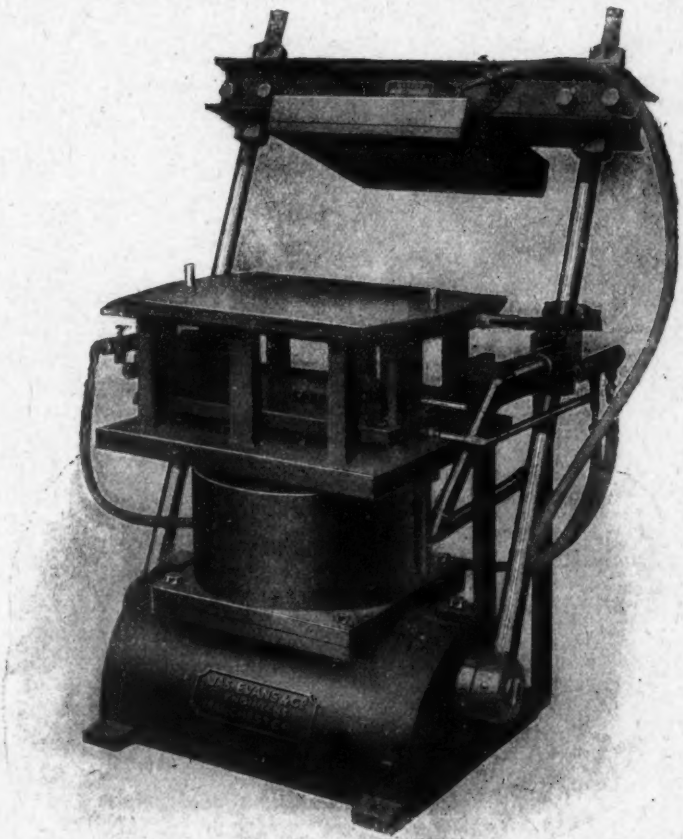

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Deaths

MR. F. MURISON, a director of Burt, Boulton & Hayward, Limited, has died at the age of sixty-nine.

MR. ALEXANDER RUTHERFORD, principal of Messrs. A. Rutherford & Company, of the Neptune Works, Birkenhead, died recently.

MR. WILLIAM ROWAN, of the firm of William Rowan & Sons, engineers, Park Lane, Mile End, Glasgow, died recently at the age of 32 years.

MR. C. H. NEVILL, J.P., principal proprietor of the St. Helens Smelting Company, Manchester and St. Helens, has died at the age of 68 years.

SIR HENRY BENBOW, late Chief Inspector of Machinery in the Navy, died at Eastbourne last month, at the age of 78 years.

THE death took place at Grimsby on October 20 of Mr. James Schofield, shipbuilder, and an authority on modern dry docks. The deceased was 67 years of age.

MR. E. E. COOPER, of Brierley Hill, a member of the firm of Roberts & Cooper, Limited, iron manufacturers, etc., Brierley Hill, died on October 20, at the age of 86.

We regret to announce the death of Mr. David Colville, managing director of David Colville & Sons, Limited, Dalzell Steel and Iron Works, Motherwell, in his 57th year.

THE death is announced of Mr. Alexander Easton Gibb at Twickenham. The deceased, who was seventy-six years of age, was head of the firm of engineers, Messrs. Easton Gibb & Son.

THE death has taken place at Monton Green, Eccles, near Manchester, of Mr. Alfred Owen, a member of the firm of Messrs Daniel Owen & Sons, ironfounders, Monton Green. Deceased had been ill for some time with typhoid.

THE death occurred at his residence, recently, of Mr. William Barraclough, head of the firm of J. Barraclough & Sons, Union Foundry, Barnsley. Mr. Barraclough, who was 62 years of age, took an intimate interest in the local social affairs.

THE death has occurred at his residence, Elmhurst, Tettenhall, of Mr. B. O. Clark, aged 66 years. He was chairman of the Wolverhampton Gas Company and member of the firm of Messrs. T. & C. Clark & Company, Shakespeare Foundry, Horseley Fields.

The death occurred at his residence at Walsall on the 19th inst. of Mr. James Bunch, in his 67th year. The deceased gentleman was the last surviving son of the founder of the firm of Benjamin Bunch & Sons, formerly one of the leading, and certainly one of the best-known, firms in the Staffordshire iron trade.

THE death occurred somewhat unexpectedly at his residence at Peterborough, last month, of Mr. E. C. Blackstone, head of the Stamford firm of engineers, Messrs. Blackstone & Company. The deceased gentleman, who was about 70 years of age, went to Stamford about 40 years ago, and established the concern which bears his name.

THE death is reported, at the age of 75 years, of Mr. James Rowe, managing director of Edward Finch & Company, Limited, Chepstow. The deceased gentleman served his apprenticeship at the company's works, commencing in the year 1857, gradually working his way up until he was elected managing director in 1873 upon the retirement of Mr. Finch, the founder of the works.

NEWS has been received in Liverpool recently of the death at Esquimalt of Mr. R. D. Keay, general manager of Yarrows, Limited, Esquimalt, who was well known both in Canadian and English shipbuilding circles. He had been with the company for some twenty years, and had acted as local general manager ever since the concern was established on the Pacific coast.

WE regret to announce that Sir Wm. Theodore Doxford, who had been in very poor health for some time past, died at his residence, Grindon Hall, Sunderland, on October 1, at the age of 76 years. The deceased gentleman, who had been prominently identified with Wearside for half a century, was a native of Sunderland, his father, Mr. W. Doxford, being the founder of the firm which has been so prominently associated with the development of the shipbuilding industry. Mr. Wm. Doxford established a considerable reputation in the building of wooden ships, starting in a small yard at the North Dock nearly 70 years ago with vessels of 150 and 200 tons register. He was afterwards associated in business with Mr. John Crown at Hylton, and later he continued on his own account at Coxgreen, where vessels as large as 500 to 600 tons were built. The year 1857 witnessed another advance in Mr. William Doxford's progress, he then entering into possession of the yard at Pallion now occupied by Messrs. Short Brothers. He then started the building of composite vessels, and in 1863 he commenced has first iron vessel. Born in 1841, Sir Wm. Doxford was educated at Bramham College, Yorkshire, and in 1857 he became associated with the business of his father.

We regret to announce the death of Mr. Richard Price-Williams, which occurred on September 19, at his residence at Bournemouth, at the age of 89 years. The deceased gentleman. In 1845 became a pupil of the late Mr. George Heald, M.Inst.C.E., the engineer employed by Messrs. Stephenson, Brassey & Mackenzie to carry out their great contracts for the construction of the Lancaster and Carlisle, Caledonian, Trent Valley, and other principal railways in this country. Mr. Price-Williams subsequently "went through the shops" as an ordinary apprentice at Messrs. Kitson's well-known locomotive works in Leeds. He was engaged as an assistant and resident engineer on the Great Northern and other railways; he was engaged in coal-mining and looking after railway business in South Wales; and he was building works and manufacturing Bessemer steel in Sheffield and at Greenwich. In his more mature years he made technical and statistical researches into the conditions of wear in permanent way and rolling stock. He was an active member of the Council of the Institution of Mechanical Engineers and of the Royal Statistical Societies. Subsequently, Mr. Price-Williams, who had become so impressed with the importance of the Bessemer process as a means of providing a much better and more durable material than iron for the permanent way of our railways, was invited to undertake the management of the works of Messrs. Samuel Fox & Company at Deepcar, near Sheffield, the result being the erection of two Bessemer converters and a large rail-rolling mill at Deepcar, and the manufacture of Bessemer steel rails there, which were at that time selling at £18 per ton. He did not receive much encouragement, however, and was almost about to despair of the enterprise, when he decided to read a paper on the whole subject. The result was the brilliant paper on "The Maintenance and Renewal of Permanent Way," which was submitted to the Institution of Civil Engineers in the session of 1866, and for which he received the Telford medal and a premium in books. This was followed, four years later, by an almost equally notable paper on "The Maintenance and Renewal of Railway Rolling-stock," for which the author was awarded a Watt medal and a Telford premium. Probably no paper that was ever read—possibly no action that was even performed—did more to put the Bessemer process fairly on its legs, for railway purposes. The inventor of the process fully appreciated the services rendered by the author of the paper, and proposed to Mr. Price-Williams to undertake the management of Bessemer steelworks which he was at that moment erecting on the Thames, at Greenwich. The offer was accepted, and the works were carried to completion; but when the price of steel fell from £18 to £7 or £8 per ton, they had to be abandoned, owing to their inability to compete with others that had the command of cheaper coal and labour. Up to his retirement from business, fifteen years ago, Mr. Price-Williams acted as a consulting engineer, and made many voyages to Australia on professional business. The Iron and Steel Institute awarded him the Bessemer Medal in 1898.

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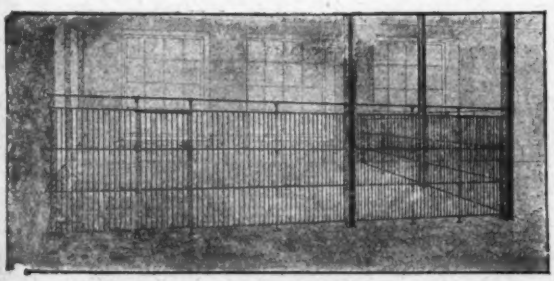

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Personal.

Mr. H. Howe has ceased to be a partner of the firm of Sayer, Howe, & Company, engineers, etc., 67, York-place, Edinburgh.

Mr. J. F. Chambers has been elected secretary of the Nottingham Society of Engineers, in place of Mr. H. G. Price, resigned.

The late Mr. E. Carlisle, formerly general manager of Messrs. Cammell, Laird & Company's works, at Workington, left estate valued at £4,607 gross.

Mr. James Cox, general secretary of the Associated Iron and Steel Makers of Great Britain, having completed 25 years' service, it is proposed to give him a national testimonial.

The late Mr. J. Tweedy, a director of the Yarrow Schlick & Tweedy System (Limited), and vice-chairman of Swan, Hunter, & Wigham Richardson (Limited), left estate valued at £60,763.

Mr. Geo. Ritchie, for many years the manager of Messrs. Beardmore's steel works, and now the general manager of Bolckow, Vaughan & Company's works, has been appointed a J.P. for the North Riding of Yorkshire.

The late Mr. L. S. Robertson, of Victoria Street, S.W., secretary of the Engineering Standards Committee, who had been attached for some months to the Ministry of Munitions, left estate valued at £10,945 gross.

Mr. E. S. Tylke, who has been actively associated with the working of the business of Lambert Bros., Limited, for the last 25 years, has been elected a managing director in the place of the late Mr. T. D. Lambert.

Mr. J. F. Nauheim has retired from the chairmanship of the British Thomson-Houston Company, Limited, of Rugby. The managing director, Mr. H. C. Levis, has been appointed chairman of the board, and also retains the managing directorship of the company.

Mr. Stephenson Kent has been appointed director-general of Munitions Labour Supply, and Mr. U. Wolff Deputy Assistant General Secretary to the Ministry of Munitions. Mr. Kent will deal generally with matters affecting labour supply; Mr. Wolff with labour questions arising under the Munitions Acts.

Mr. H. E. Morgan, of the Labour Supply Department of the Ministry of Munitions, has been temporarily detached by the Minister for the purpose of proceeding to Canada to advise the Imperial Munitions Board, Canada, of the procedure adopted in this country in connection with labour in munition factories.

Mr. R. B. Sheridan, formerly a representative of the Brown Hoisting Machinery Company, in London, has been elected president of the Allied Machinery Company, New York, organised for the purpose of marketing American machine tools in Europe, and recently acquired as a subsidiary by the American International Corporation.

Commander E. H. M. Nicholson, D.S.O., R.N., has been elected a director of Hadfields, Ltd., East Hecla Works, Sheffield. Commander Nicholson was invalided from the service in 1906. He then went to the Admiralty, on the staff of the Director of Naval Ordnance, and was shortly afterwards appointed to the Inspection Staff at Woolwich, and from thence to Sheffield.

Mr. Douglas Vickers has presented to the Sheffield Cutlers' Company, on his retirement from membership, £1,000 4½ per cent. War Loan as a memorial of his connection with the company. The increasing calls upon Mr. Vickers' time and his frequent absences from Sheffield on the business of Vickers, Limited, of which he is a managing director, have necessitated his decision to resign from membership of the Cutlers' Company, of which he is a Past-Master. Mr. William Clark, a director of Vickers, Limited, has been elected to succeed him.

A successful effort has been made to provide for one of the children of the late Mr. G. Hailstone, of Smethwick, analyst and metallurgist and Carnegie scholar, by securing his admission into the Royal Orphanage, Wolverhampton. The matter was taken up by Mr. H. L. Reason and Mr. S. W. B. Stephen, of the British Foundrymen's Association. As the elections to the Orphanage are by the votes of subscribers, a special subscription was raised in order to increase the number to be cast for the candidate. An appeal to members of the British Foundrymen's Association brought in a sum of £45, whilst a further sum, bringing the total to £166 6s. 6d., was raised mainly through the efforts of Mr. Stephen. At the election, on October 3, the candidate, George John Hailstone, aged nine, headed the list with 2,190 votes.

New Companies.

Creighton Construction Company, Limited.—Capital £10,000 in £1 shares.

Selson Engineering Company (Italy), Limited.—Capital £3,000 in 3,000 £1 shares.

Taylor Bros. (Sandiacre), Limited.—Capital £10,000 in £1 shares, to carry on the business of ironfounders.

M. C. Ritchie & Company, Limited.—Capital £7,000 in £1 shares, to carry on the business of engineers. Registered office: 145, Farringdon Road, E.C.

S. P. A. R. Manufacturing Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of ironfounders, etc. Registered office, 5, Peakman Street, Redditch.

The La Bassee Shell Company, Limited.—Capital £5,000 in £1 shares, to carry on the manufacture of munitions of war. Registered office, 231, Elliott Street, Glasgow.

Clyde & Company, Limited.—Capital £10,000 in £1 shares, to take over the business of merchants and engineers carried on at Exchange Buildings, Middlesbrough, as Clyde & Company.

A. M. Petit & Company, Limited.—Capital £5,500 in 5,000 pref. shares of £1, and 10,000 ord. shares of 1s. to carry on the business of merchants, engineers, etc. Registered office, 58, Lombard Street, E.C.

Lancashire Steel & Iron Company, Limited.—Capital £10,000 in £1 shares, to adopt an agreement with C. Bemant. Registered office: 8, Waterloo Place, Pall Mall, S.W.

T. S. Harrison & Sons, Limited.—Capital £10,000 in £1 shares (2,000 6 per cent. cumulative preference), to carry on the business of engineers. Registered office: Crystal Mills, Liversedge, Yorks.

Taylor Bros. (Sandiacre), Limited.—Capital £10,000 in £1 shares, to take over the business of ironfounders, etc., carried on by C. H. Taylor and J. Taylor, at Sandiacre, Derby, as Taylor Bros. The first directors are H. L. Taylor, A. J. Taylor, and L. Taylor.

Alfred H. Mould & Sons, Limited.—Capital £10,000 in £1 shares (2,000 six per cent. cumulative preference, to take over the business of a malleable and general ironfounder carried on by A. H. Mould, at Imperial Works, Stafford Street, Walsall, as Joseph Bullows & Company.

West Bromwich Casement & Engineering Company, Limited.—Capital £5,000 in £1 shares, to take over from E. S. Fullwood, C. P. Landon, B. P. Gibney, and J. O. C. Hardiman, the business of engineers carried on by them at West Bromwich, as the West Bromwich Casement Company.

Robson Machine Tool Company, Limited.—Capital £50,000 in £1 shares (30,000 6 per cent. cumulative preference), to take over the business of engineers and ironfounders carried on by Roberts & Company, Limited, at Union Works, Cutler Heights, Bradford. The first directors are G. Barrett, E. Barrett, V. Calverley, W. J. Hinde, R. A. Vinter, and W. A. Wallis.

Wadkin, Mills & Company, Limited.—Capital £10,000 in £1 shares, to take over the business of a pattern and machine and mechanical tool and optical and nautical instrument maker, carried on by J. W. Wadkin at Greyfriar Gate, Nottingham, as the Pattern Making Machine and Mechanical Tools Company. The first directors are J. W. Wadkin (chairman) and R. K. Mills (both permanent).

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.

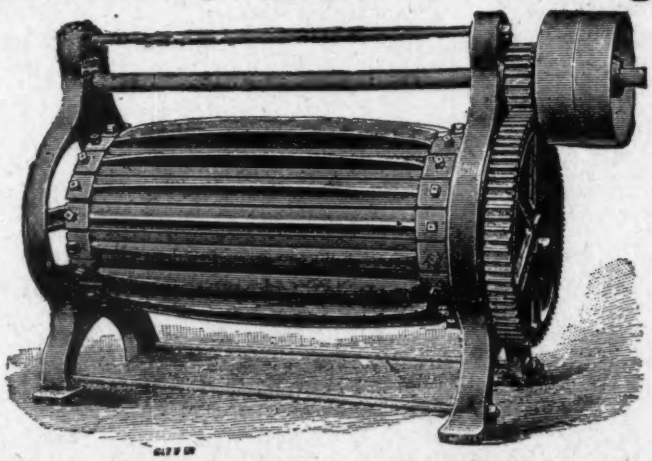
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

These maximum prices of iron, steel and coke were fixed by the Government until June 30, 1916, and thereafter until further notice. Makers may sell for delivery after June 30, on the understanding that the fixed maximum prices ruling on the 1st day of any month during the period of the contract will apply to all deliveries made during that month. This intimation must not be taken to authorise any sale or purchase or other dealing prohibited under the Defence of the Realm Regulations

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos., 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Lincolnshire, basic or foundry ..	4	12	6
Cleveland, No. 1	4	11	6
„ other grades	4	7	6
Northamptonshire, forge	4	7	6
„ fdy. numbers	89/0		94/0
Derbyshire, forge	4	10	0
„ foundry numbers	92/6		96/6
Derby & Notts. basic. ..	4	17	6
Leicestershire & Notts., forge ..	4	10	0
„ „ foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
„ „ foundry	4	17	6
„ „ basic	4	17	6
South Staffordshire—			
Part mine forge	4	15	0
„ foundry	4	17	6
Common Staffordshire ..	4	10	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1½%

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Extras as per authorised list These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	5d
Bar Ends	6d

Both per lb. net delivered steel makers works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	38	0	0
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	36	0	0
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	34	0	0
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	120	0	0
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	0	15	0
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	28	10	0
Ferro-titanium: 23/25%, per lb. carbonless..	0	1	5
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	0	16	0
Ferro-phosphorus: 20/25%. Per ton	16	10	0
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	0	5	6
*Ferro-manganese 80%	25	0	0
„ export 30 0 0—35	0	0	

* F.o.b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	124	0	0	124	10	0
Three months	119	0	0	120	0	0
Electrolytic	145	0	0	141	0	0
Tough	142	0	0	146	0	0
Best selected	143	0	0	147	0	0

Tin.

Standard, Cash	182	5	0	182	10	0
„ Three months	183	10	0	183	15	0
English Ingots	—			183	10	0
Bars	—			184	10	0
Refined	—			186	10	0

Spelter.

American	—			54	0	0
Specials	—			—		
Hard	—			43	0	0
British	—			56	0	0

Lead.

Soft Foreign	—			30	10	0
English	—			32	7	6

Antimony.

Regulus	—			85	0	0

Aluminium.

Virgin Metal 98/99% per ton	155	0	0	200	0	0

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—
CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
„ Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. 35/- above price of best selected copper.

15 per cent. Phosphor Copper .. 40/- above price B.S.

Phosphor Tin (5 per cent.) .. £23 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM).

***Chromium (Metallic).**

98/99% purity, per lb.	—	0	5	9

***Nickel.**

In cubes, 98/99% purity Per ton	220	0	0	

Nickel Silver.

	per lb.
Ingots for raising	2/0 to 1/6
Ingots for Spoons and Forks ..	2/0 to 1/5½
„ rolled to spoon size ..	2/1½ to 1/7

***Tungsten Metal Powder.**

96/98% purity.. per lb. ..	0	6	3	

***Molybdenum Metal.**

96/98% purity.. per lb. ..	—

***Cobalt Metal.**

97% purity .. per lb. ..	0	7	6	

Quicksilver.

75 lb. bottle	17	13	9	

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	£	s.	d.
Steel scrap, heavy melting..	110	0		—	
Iron scrap cast (cupola metal)	—			85	0

London (f.o.b.).

Heavy steel	85	0	
Light	45	0	
Heavy cast	80	0	

Control Prices.

Heavy Steel Melting Scrap ..	5	10	0
Turnings and Borings	2	15	0

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	135	0	0
Hy. Selected Scrap Brass ..	76	0	0
Hy. Tinned Copper Wire	120	0	0
Best Selected Gunmetal Scrap ..	100	0	0

Re-melted Ingot Lead 30s. under English Lead price on date of order.

Stocks.

Metals.	Tons.
Copper, Europe and afloat	15,231
Tin, London, Holland, U.S.A. and afloat	18,821

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	32	6	—	

Glasgow.

Foundry Coke	—		42	6
Furnace Coke	31	0	—	
Gas Coke	—			

London.

Welsh or Durham Foundry, d/d London Stations in truck	45	6	53	0
Ditto, d/d Birmingham Stations	44	0	48	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6	—	

CONTROL PRICES OF COKE.

	s	d.
Durham and Northumberland blast furnace	28	0
„ foundry	30	6
South Yorkshire, West Yorkshire, Lancashire, Staffordshire and Midland Counties blast furnace	25	8
South Wales blast furnace ..	30	0
„ foundry	43	0

All per ton net. f.o.t. ovens.

SITUATIONS VACANT AND WANTED.

BRASS FOUNDRY. — Wanted, for small brass foundry in London, on war work, a competent Foreman; must be over age or otherwise ineligible; good prospects for the right man.—Write, Box 848, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

MOULDERS (General) required for immediate Government work. Experienced men used to high class petrol motor work. Good wages and prospects; War Bonus and overtime. No man on Government work will be engaged.—Write or apply in first instance to your nearest Board of Trade Labour Exchange mentioning this paper and No. A. 2327.

WANTED, in Belgian Metallurgical Works, Good Draughtsman, experienced in installations, mechanical work.—Reply G. B. 40, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

WANTED, by important ironfoundry, Good Travelling Representative, possessing large clientèle in London and neighbouring provinces.—Reply G. B. 40, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

WANTED, Foreman for Foundry. State age and experience. Persons employed on Government work need not apply.—Box 840, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

CLERK required for Foundry Office. Persons employed on Government work need not apply.—Write, stating age, experience, etc., to Box 842, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

WANTED, Competent Foundry Manager, must be thorough organiser; machine moulding; repetition work. Persons employed on Government work need not apply.—C. & J. HAMPTON, Limited, Attercliffe, Sheffield.

FOR SALE AND WANTED.

SURPLUS PLANT FOR SALE.

ONE Patent Horizontal Sand Mixer, fitted with special oscillating cover, 2 grids, and 3 sets of beaters. Ball bearings to main shafts. Capacity 3 to 4 tons per hour. Complete with countershafts and belt striking gear. By the London Emery Works Company. In perfect condition, equal to new.

1 Flat Table Hydraulic Moulding Machine, table fitted with 4 lifting pins and arranged to take moulding boxes 50in. by 17½in. Complete with wooden rammer blocks to press head. By London Emery Works Company. Equal to new.

1 ¾in. Hydraulic Stop Valves, complete with flange and joint washers.

42 Moulding Boxes, 50in. by 17½in., with planed faces.
2 Iron Pattern Frames for plaster blocks.

42 Moulding Boxes, 26in. by 21½in.

Also a quantity of hydraulic piping, ¾in. and 1¼in., fitted with T connections.

GEO. HATTERSLEY & SONS, LIMITED, Keighley.

FOR SALE AND WANTED.—*cont.*

ONE good Second-hand No. 2 Roots' Blower, belt-driven both ends, about 12in. pulleys, good gearing, 8 in. diameter outlet underneath, wooden vanes, ready for prompt delivery.—MARPLE & GILLOTT, LIMITED, Sheffield.

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply, HALL, 26, Paradise Square, Sheffield.

WANTED, Sandblast Rattler, complete with air compressor, to do 5 ton per week.—Box No. 846, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

12 IN. Roots' Blower, by Dempster, driven direct by horizontal steam engine; 8-in. ditto, by Thwaites, with vertical engine, self-contained; low price; immediate delivery.—WILLIAMS & SONS, South Bermondsey Railway Station, London, S.E.

REFINED ALUMINIUM INGOTS

NOTCHED BARS.

SPECIFICATIONS GUARANTEED.

MIDLAND METAL CO., COVENTRY

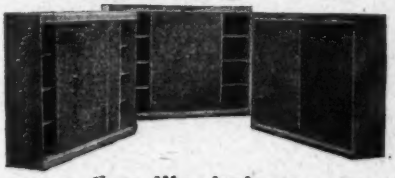
PATTERN SHOP SUPPLIES.

Wires: "Requisites, Birmingham." **J. BURN & CO.,** 'Phone: 137 Victoria.

Henshaw Road, Small Heath, BIRMINGHAM.

SANKEY

Fireproof Steel Storage Bins



For Workshop and Warehouse.

Write for Details.

Joseph Sankey & Sons, Ltd.,

Hadley Castle Works, Wellington, Shropshire.

PLUMBAGO—CRUCIBLES.

Parting Powder.

William OLSEN,

Cogan Street, HULL.

FOUNDRY MATERIALS AND REQUISITES.

Largest Stock of Straw and Wood Fibre CORE ROPINGS.

Wax Core Vent.

GLUTRIN—CORE GUM.

FIRE BRICKS & CLAY

CUPOLA BRICKS.

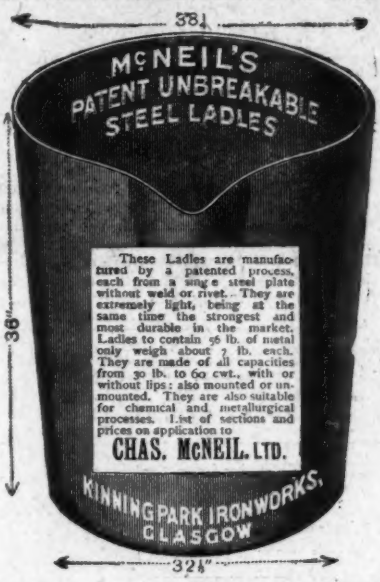
Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

KING BROTHERS,

(STOURBRIDGE) Ltd.,

STOURBRIDGE.

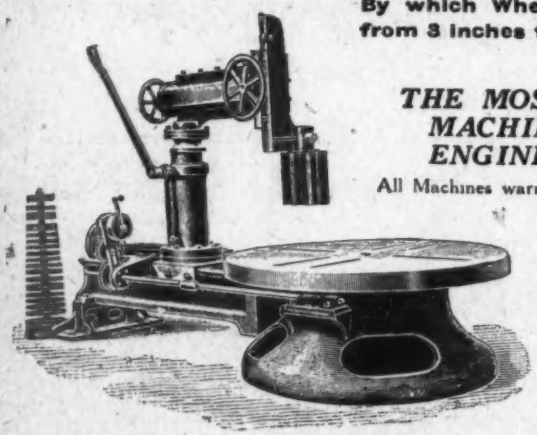

38½
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips: also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL, LTD.
KINNING PARK IRONWORKS,
GLASGOW
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

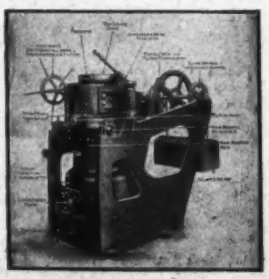
WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS,* *OLDHAM.

Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

PAGE.	NAME.	ADDRESS.	TELEGRAPHIC ADDRESS.	TELEPHONE NO.
671	Adaptable Moulding Machine Co.	Stanhope Street, Birmingham	"Adaptable"	1966 Mid.
	Alldays & Onions, Ltd.	Birmingham	Alldays, Birmingham	28 Victoria
627	Anglo-Mexican Petroleum Products Co., Ltd.	Finsbury Court, Finsbury Pavement, E.C.	Mexproduct, Ave, London	City 2704
666	Baldwin (Aston) Ltd., J. & W.	Aston, Birmingham	"Splinters" Birmingham	254-5 East.
627	Braby, F. & Co., Ltd.	Petershill Road, Glasgow	Braby, Glasgow	—
C. iii.	Bradley, T. & I. & Sons, Ltd.	Darlaston	Bradley, Darlaston	—
630	Britannia Foundry Co.	Coventry	Stoves, Coventry	251
622	British Binderit Co., Ltd.	Wharf Road, Wandsworth, S.W.	Bindercomp, Wands., London	994 Putney
C. ii.	British Thermit, Co., Ltd.	40 & 51 The Albany, Liverpool.	Thermetal, Liverpool	1680 Central
629	Broadbent, T. & Sons	Huddersfield	Broadbent	1581 (4 lines)
C.iv.	Buckley & Taylor, Ltd.	Castle Iron Works, Oldham	Engines, Oldham	Oldham No. 8
	Burn, J. & Co.	Small Heath, Birmingham	"Requisites," Birmingham	137 Victoria
620	Constable & Co.			
	Corebind, Ltd.	5, Castle Street, Finsbury, London, E.C.	"Corebind," Castle St., Finsbury	9029 Wall
623	Cumming, William & Co., Ltd.	Maryhill, Glasgow	Prudence, Glasgow	P.O.M. 25
667	Davidson & Co., Ltd.	Belfast	Sirocco, Belfast	4341 Belfast
	Davies, T. & Son	West Gorton, Manchester	Tuyer, Manchester	70 Openshaw
669	Durrans, Jas. & Sons	Penistone, nr. Sheffield	Durrans, Penistone	21 Penistone
630 & 665	Evans, J. & Co.	Manchester	Ladles, Manchester	2297
626	Everitt & Co.	40, Chapel Street, Liverpool	Persistent, Liverpool	1134 Central (3 lines)
626	Fyfe, J. R., & Co.	Shipley, Yorks	Brick, Shipley	59 Shipley
667	Gibbons, James	Wolverhampton	—	—
	Glasgow Patent Moulders Blacking Co.	26, Fleming St., Port Dundas, Glasgow	Moulders, Glasgow	—
618	Goldendale Iron Co., Ltd.	Tunstall, Stoke-on-Trent	Goldendale, Tunstall, Staffs	—
628	Gray, Thomas E. & Co.	3—4, Lincoln's Inn Fields, Kingsway, London, W.C.	Papplewick, Holb, London	1946 Holb.
626	Hall, John & Co. (Stourbridge), Ltd.	Fire Clay Works, Stourbridge	Hall, Stourbridge	55 Stourbridge
625	Hedley Moorwood & Co., Ltd.	21, Church Street, Sheffield	Morod, Sheffield	4318
	Hislop, R. & G.	Paisley	Gas, Paisley	331 Paisley
623	Keith, James & Blackman Co., Ltd.	27, Farringdon Avenue, London	James Keith, London	6194 H'lb'rn (4 lines)
671	King Bros. (Stourbridge), Ltd.	Stourbridge	King Bros., Stourbridge	—
620	Lawson Walton & Co.	2, St. Nicholas Bldgs, Newcastle-on-Tyne		
667	Lowood, J. Grayson, & Co., Ltd.	Deepcar, nr. Sheffield	Lowood, nr. Sheffield	18 Stocksbridge
620	Mansergh, T. E.	Wheathill Charcoal Works, Salford	—	—
	Marshall, H. P. & Co.	Leeds	Speciality, Leeds	1909 Leeds
	Metalline Cement Co.	112, Bath Street, Glasgow	Adhesive, Glasgow	201 Y2 Douglas
672	McNeil, Chas., Ltd.	Kinning Park, Glasgow	McNeil, Glasgow	X 155
671	Midland Metal Co.	Coventry	—	—
617	Monometer Manufacturing Co., Ltd.,	Whitehouse St., Aston, Birmingham	—	—
621	Naish & Croft	150, Alma Street, Birmingham	—	—
672	Olsen, William	Cogan Street, Hull	Wm. Olsen, Hull	Nat. 1184
C. iii.	Phillips, J. W. & C. J.	23, College Hill, E.C.	Colloquial, London	10112 Central
629	Portway, Chas. & Son	Halstead, Essex	Portway, Halstead	10 Halstead
619	Samuelson & Co., Ltd.	Banbury	Samuelson, Banbury	17 Banbury
671	Sankey, Joseph & Sons, Ltd.	Hadley, Salop	Sankey, Hadley	—
621	Stewart, D. & Co., Ltd.	London Road Iron Works, Glasgow	Stewart, Glasgow	71 P.O. Bridgton & 3243 Bridgton (N.)
C. i.	Stott, Ltd., Oswald	Corporation Street, Birmingham	Blowing, Birmingham	2525 Central
626	Spermolin Core Co.	Spermolin, Halifax	Halifax	397
C. ii	Thermit Ltd.	675, Commercial Road, E.	Fulmen, Step, London	East 4157
	Tilghman's Patent Sand Blast Co., Ltd.	Broadheath, nr. Manchester	Tilghmans, Altrincham	14
624	Thwaites Bros., Ltd.	Bradford	Thwaites, Bradford	3456 & 3460 Brdf'd.
628	Universal Machinery Corporation, Ltd.	326, Old Street, London, E.C.	Toolcraft, London	3763 London Wall.
621	Walker, I. & I.	Rotherham	—	—
	Walco, Ltd.	53, Newton Street, Birmingham	Walco, Birmingham	Central 3305
672	Whittaker, W. & Sons, Ltd.	Oldham	Whittakers Engineers, Oldham	83
629	Wilkinson, Thos. & Co., Ltd.	Middlesbrough	Blacking, Middlesbro'	419
	Williams, J. (Birmingham Sand), Ltd.	Birmingham	—	—



Monometer Patent Tilting Furnace.

BRASS CASTING OUTPUT.

2 Monometer Metal Melting FURNACES,

Tilting Type, 800 lbs. Capacity, Oil-Fired (Hall's Patents).

3 MEN working double shift and operating two furnaces produce this output, a result unattainable by any other system on the market

24,000 lbs. of Bar Brass 2½" × 40" cast also Brass, Copper, Admiralty Metal, Gun Metal, Scrap, Turnings, etc., in 24 hours.

No Carbon Deposit or Smoke. Consumes Crude, Residual, Anglo-Mexican, Creosote, Texas, and Tar Oils and Waste Product from Gas Works

Abundant Supply of Fuel. Clean, Healthy, and Foolproof.

Life of Brick Lining 100% greater than any other on the World's Market.

Life of Crucibles app. 65 melts and upwards. Segmental Spigot Joint-Sections easily renewable.

Uses Commercial Crucibles without Special Spouts.

Constant Vertical Pouring Point Monometer Mould Carrying Turntable. Most rigid, massive, and scientifically designed and constructed Furnace on the World's Market.

Cupro Nickel, Ferro-Manganese and other high fusing-point alloys or metals rapidly melted in proportionate time.

MONOMETER Mfg. Co., Ltd., Engineers and Ironfounders,

Edited by I. H. Hall, Managing Director. ASTON, BIRMINGHAM, England.

GOLDENDALE CYLINDER PIG IRON.

MAKERS:

GOLDENDALE IRON CO.,

STOKE-ON-TRENT.

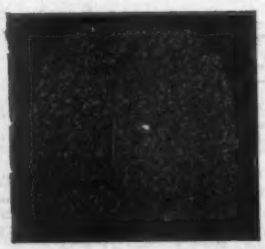
NOTE THE FOLLOWING POINTS—

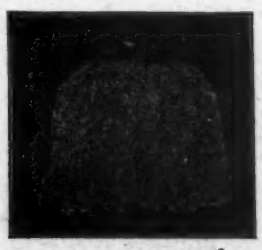
1. Dense with close grey fracture.
2. Melts hot and exceedingly fluid and will fill every corner of your Mould.
3. Easy to Machine.
4. Absolutely sound.

WE MAKE A SPECIAL QUALITY FOR

MOTOR CYLINDERS.

Contractors to the Admiralty, Principal Railway Companies and Engineers at Home and Abroad.





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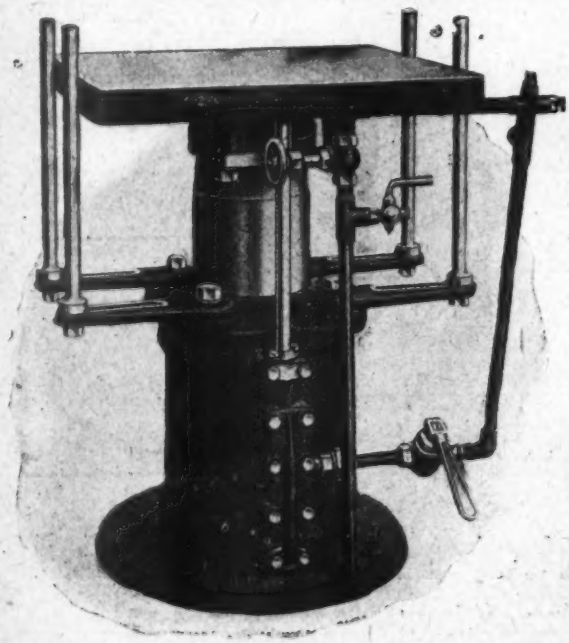

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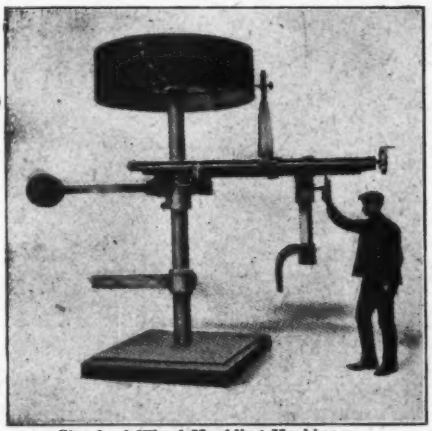

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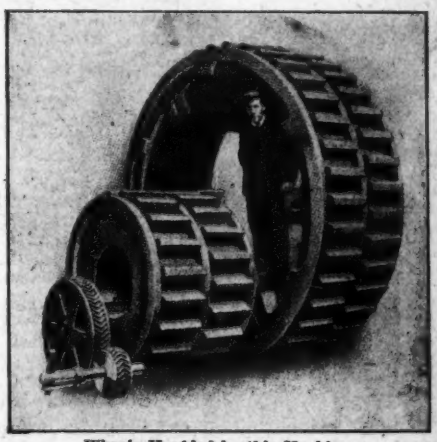

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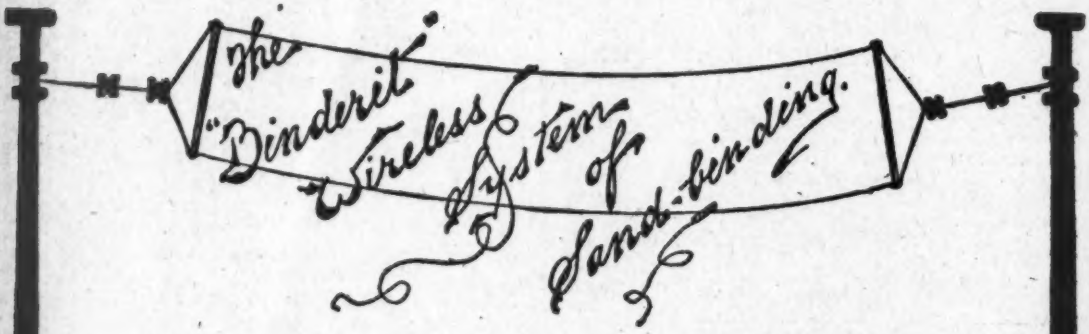

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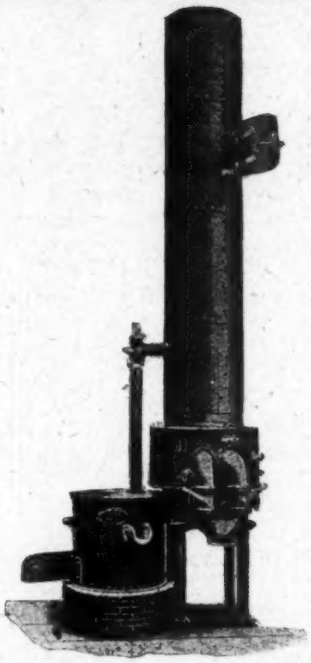

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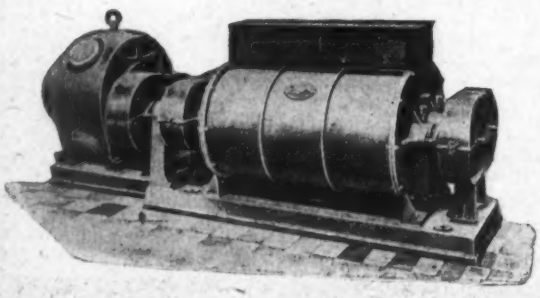

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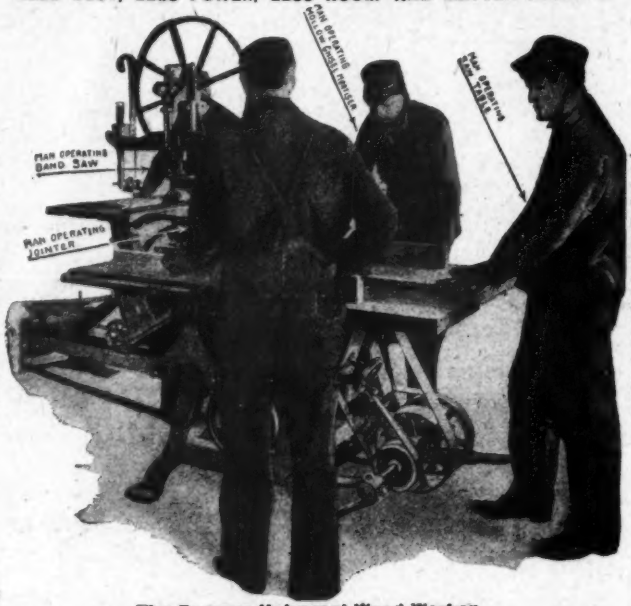

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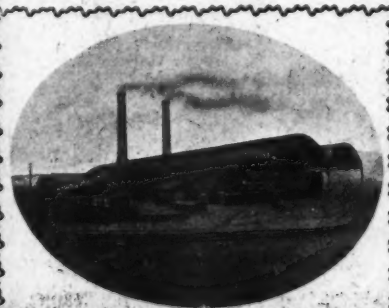

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